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SCIENTIFIC RESULTS OF THE SECOND OCEANOGRAPHIC
EXPEDITION OF THE "PAWNEE"

1926

DEEPSEA FISHES FROM OFF THE WESTERN
COAST OF NORTH AND CENTRAL AMERICA

BY ALBERT EIDE PARR

Curator of the Bingham Oceanographic Collection

INTRODUCTION

During the second oceanographic expedition of the "Pawnee," under the direction of Harry Payne Bingham, with Mr. L. L. Mowbray, now of the Bermuda Aquarium, acting as naturalist on board, a limited number of bathypelagic hauls were made with fair success at a short series of stations off the western coast of Mexico and Central America from approximately 25° N., in the Gulf of California, to 11° N., off Nicaragua, as shown on the accompanying map. The various samples of deepsea fishes obtained from these hauls have been turned over to the writer for identification and description in conjunction with the work on the deepsea material from the third expedition of the "Pawnee" during 1927 (see Bull. Bingham Oceanogr. Coll., Vol. III), the shallow water fishes of the second expedition having already been reported upon by Mr. C. M. Breder in the preceding articles of the present volume.¹ The following information concerning the collecting of the material with which we are here concerned has been obtained by compilation from the captain's log book for the cruise and from the labels found in the various jars.

Most of the stations, excepting only the one off Cape San Lucas April 17 and one of the two stations made on May 28, were occupied during the evening, the net being lowered over the side around 6 to 6:45 P.M. to be pulled on board again about 2-3 hours later. A circular net of twelve feet diameter at the opening was employed for all hauls in the series here reported upon and was always kept at a depth equalling only a small fraction of the total depth to the bottom

¹ Article 3 still to be issued.

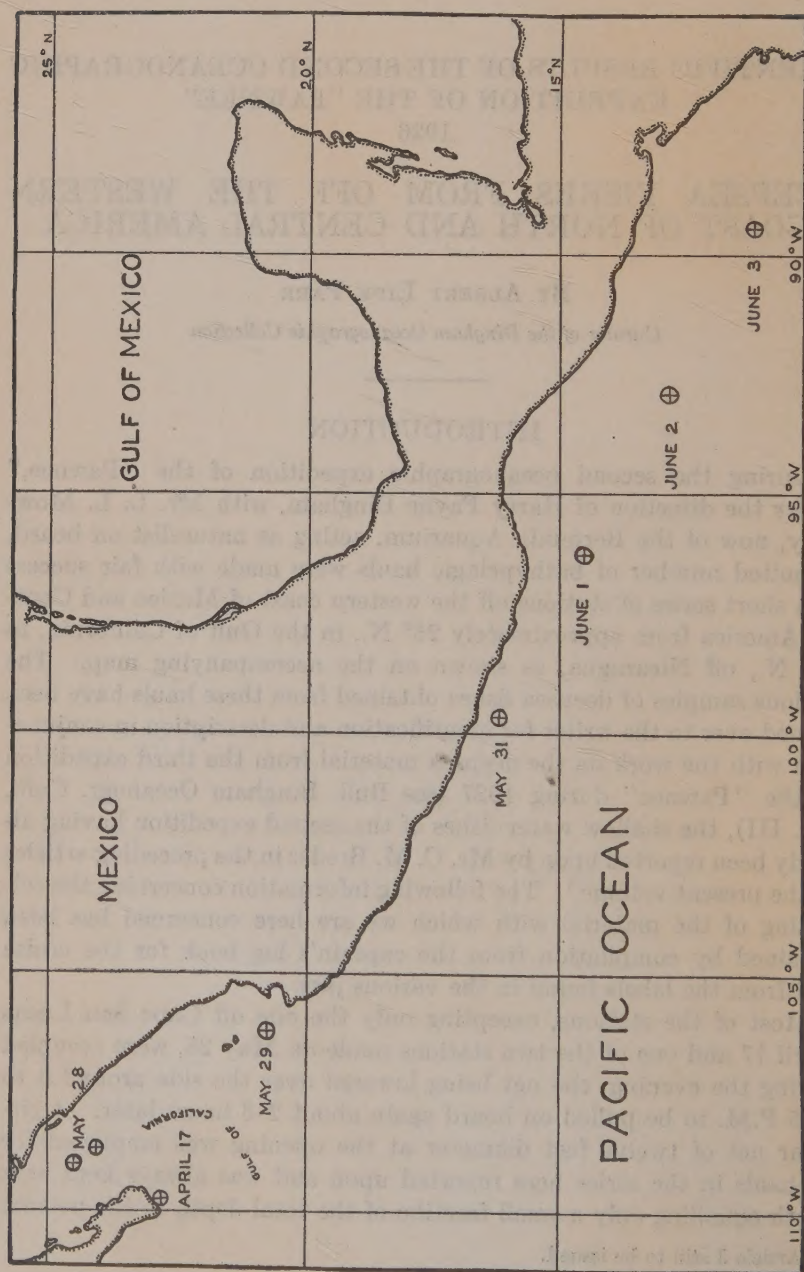


Figure 1. Map of stations at which deep sea fishes were collected.

in the various localities in which it was used, except at the station occupied off Cape San Lucas on April 17 in the afternoon, where it would seem from the records that an attempt was made to reach the bottom. This attempt has apparently been unsuccessful, however, judging from the samples obtained; while another haul made earlier during the same day, but from which we have no fishes preserved, resulted in the trawl hooking up on the bottom. Apart from the samples from the haul of April 17th there can, however, as above made out, be absolutely no doubt whatever as to the truly pelagic nature of the catches obtained, although there is some slight confusion in the records arising from an inconsistency in the method of designating the fishing depth of the net, the figures obtained from the labels for the two stations made during May 28 apparently representing estimated vertical depth of the gear, while for the other stations, for which the figures have been taken from the captain's log book, the records merely refer to the length of the cable paid out from the ship. It is unfortunate that this entry is missing from the log book for May 28.

A couple of jars have been found to contain no field-labels at all, but it is highly probable that these samples were obtained at the station occupied during June 2, since the log book refers to a successful haul in this location, which is not represented, however, among the labelled samples.

A single specimen of the genus *Psenes*, and two very small Brotulids have been reserved for future study, the samples at hand having been found inadequate for a proper determination of the taxonomic status of the forms involved. A revision of the genus *Psenes*, and related genera, may be attempted later in connection with the further reports on the fishes of the third oceanographic expedition of the "Pawnee."

LIST OF NEW GENERA, SPECIES AND SUBSPECIES

Bathylagus nigrigenys, n. sp.

Bathylagus longiceps, n. sp.

Diplophos proximus, n. sp.

Lestidium pacificum, n. sp.

Lampanyctus omophus, n. sp.

Lampanyctus idostigma, n. sp.

Lampanyctus omostigma parvicauda, n. subsp.

Diaphus pacificus, n. sp.

Melamphaes macrocephalus, n. sp.

DOLICHODON, n. gen.

Dolichodon normani, n. sp.

Another new genus (*Scopelarchoides*) and species (*S. nicholsi*) obtained by the same expedition has already previously been described by the writer (Parr 1929, pp. 14 and 16).

ISOSPONDYLI

SALMONOIDEA

Family ARGENTINIDAE

Genus *Bathylagus* Günther

Bathylagus nigrigenys, n. sp.

2 specimens, No. 2673 B. O. C. May 29, 1926. 20° 48' 15" N. 106° 11' 50" W. 540 fathoms cable out.

12 specimens, No. 2674 [TYPE] and 2675 [cotypes] B. O. C. May 31, 1926. 16° 14' N. 99° 36' 30" W. Depth to bottom 1800 fathoms. 625 fathoms cable out.

An adequate account of the general appearance and numerical characteristics of the species will be found in the accompanying illustration and in the following table of counts and measurements.

COUNTS AND MEASUREMENTS OF *Bathylagus nigrigenys*, n. sp.

Total length without C. in mm.		82.5 ¹	73.5	65.0	65.0	62.5
Greatest depth	In per cent of total length without C	19.7	19.7	20.0	20.0	21.6
Length of head		24.8	27.2	28.0	26.5	27.6
Length of snout		5.0	4.8	5.4	5.4	5.1
Diameter of eye		7.9	8.2	7.7	8.5	8.5
Interorbital width I ²		8.5	8.5	8.5	9.2	8.8
Interorbital width II ²		5.0	4.1	4.0	4.6	4.0
Snout to V.		60.0	62.0	58.0	58.0	59.0
Snout to D.		52.0	53.0	54.0	52.0	54.0
Snout to A.		79.0	80.0	78.0	77.0	77.0
D		11	11	11	12	11
A		14½	14½	17	15	15

¹ Type specimen.

² For explanation, see the text.

The interorbital width has first been measured (I) as the full width between the external free margins of the thin lamella-like supraorbital expansions of the frontals; and secondly (II) as the width of the solid interorbital portion of the cranium only; both measurements having been used in the previous literature on the genus *Bathylagus* for the definition of various species.

The mouth is very small, strongly oblique (without the lower jaw being prominent), and almost entirely transverse, the maxillary scarcely reaching more than halfway to the anterior margin of the eye in lateral view. The length

of the maxillary in the type specimen equals about 5.5 per cent of the total length without caudal fin.

The gill membranes are broadly united ventrally and the gill slits extend upward to the level of the upper margins of the eyes, far above the pectoral fin-bases. Only 2 gillrakers can be found.

The depression of the ventral profile in the thoracic region is not in this species, as it probably is in Goode and Bean's figure of *B. euryops* (Goode and Bean 1895, fig. 63), due to a "projection of the hyoid apparatus" (Holt and Byrne 1913, p. 25), but to the normal structure of the shoulder girdle, and is seen in all of the 13 specimens now at hand.

P. 10. V. 8-10. D. 11-12. A. 14-17. 41 vertebrae (cotype), upturned centra counted as one.

Teeth in lower jaw fairly well developed, those in the premaxillaries minute. There are a few small teeth in an irregular group at the anterior end of the vomer.



Figure 2. *Bathylagus nigrigenys* n. sp.

Pigmentation of external surfaces moderate, the tail, the upper half of the trunk and the dorsal surface of the head being of a fairly uniform dusky brown color, while the lower half of the trunk and the lateral and ventral surfaces of the head are quite pale externally. Peritoneum and the inner lining of mouth and gill cavity jet black, conspicuously visible from the exterior, particularly through the gill cover, which therefore appears to be of a highly lustrous black hue.

To make an actual count of the scale pockets is not possible on any of the specimens, but a rough estimate would place the probable number of scales at somewhere between 40 and 45.

6-7 pyloric coeca.

In the key to the genus *Bathylagus* recently rendered by Norman (1930, p. 272), *B. nigrigenys* would fall under division I, with dorsal fin nearer to base of caudal than to the snout. Within this division our new species seems differentiable from *B. argyrogastrer* by its smaller eyes (3 to $3\frac{3}{8}$ in head, $2\frac{1}{2}$ to $2\frac{3}{4}$ in *B. argyrogastrer*) and more numerous anal rays (only 13 in *B. argyrogastrer*). The

third species in the same division (*B. milleri*) differs by having only 8 dorsal rays, instead of 11 to 12 as in *B. nigrigenys* and in *B. argyrogaster*.

***Bathylagus longiceps*, n. sp.**

6 specimens, No. 2712 B. O. C. April 17, 1926. 22° 50' 20'' N. 109° 48' 15'' W. 525 fathoms.

1 specimen, No. 2711 B. O. C. (TYPE) May 28, 1926. 24° 07' N. 108° 40' W. 286 fathoms.

It is not without considerable hesitation that this species is herewith provisionally referred to the genus *Bathylagus*, with which, however, it agrees in having only two branchiostegal rays and in having the gill membranes united and free from the isthmus. In general appearance *B. longiceps*, on the other hand, differs very conspicuously from the other members of the genus *Bathylagus* particularly by its relatively long and pointed snout, and by the great length of its head (fully one third of the total length without caudal fin, as compared with about one fourth (5/19) to less than one fifth of this measurement in the other



Figure 3. *Bathylagus longiceps* n. sp.

species). By these features the new species is easily recognizable from all other known forms, and no further discussion of its taxonomic differentiation does therefore seem necessary.

The material is unfortunately in a rather poor condition, being considerably torn and twisted, but the type specimen, measuring 42 mm. without caudal fin, gave, with fair accuracy, the following proportions in per cent of the said measurement. Greatest depth 16.5. Depth of caudal peduncle 8.3. Length of head 34. Length of snout 9.5. Horizontal diameter of eye 9.5. Interorbital width of the skull 4.8. Width between the free surfaces of the eyes (dermal eye openings) 9.0. Length of maxillary 10.5. Snout to dorsal fin 58. Snout to ventral fin 64. Snout to anal fin 79. The rest of the material shows a good general concordance with these proportions.

D. 9. A. ca. 12. V. 8. P. ?. There are no indications of scales; which, however, does not disprove the possibility of their having become accidentally lost, in view of the condition of the specimens. 39 vertebrae (cotype), upturned centrum counted as one.

Upper profile of the head gently ascending in a perfectly straight line from the point of the snout to the nape. Maxillary expanded posteriorly, just reaching

to the vertical from the anterior margin of the eye. Mouth oblique, lower jaw prominent. Eyes slightly oval, their horizontal diameter somewhat longer than the vertical. Body slender, compressed. Ventrals under the posterior portion of dorsal fin, adipose dorsal above the posterior half of anal.

A single row of very fine teeth in premaxillaries and dentaries, conspicuously longer in the latter. Two (?) transverse series of about four minute teeth each across the vomer, and a series of very minute teeth on each palatine.

Dorsal half dotted with a very coarse, black pigmentation, ventral half pale (externally). Peritoneum and the inner lining of the buccal and branchial cavities, including the inside of the gill cover and the branchiostegal membrane, deep black, and conspicuous from the exterior around mouth, gill covers and abdomen.

STOMIATOIDEA

Suborder LEPIDOPHOTODERMI¹

Family **STOMIATIDAE**

Genus **Stomias** Cuvier

In the following key the author has attempted to give a provisional instrument for the identification of the various species referred to the genus *Stomias* by critical compilation from the published accounts and descriptions. In the synonymies of the various forms have only been entered such designations as have been introduced for presumably new species or subspecies (varieties) since the publication of Brauer's key to the same genus (Brauer 1906, p. 46). For earlier synonymies the reader must therefore be referred to Brauer's account.

Several species of the genus *Stomias* are still found to be based upon the counts and measurements of one single specimen only, and the taxonomic status of these forms can not be regarded as definitely established until confirmed by a study of their individual variations within a larger material, in view of the quite considerable ranges of variation observed among the better known species.

Tentative key to the genus *Stomias*

- A. Premaxillaries with only 4-7 teeth, larger than, or at least equal to those of the dentaries.

I. Ventral row of photophores: V-A.² 5-6. P-V.³ 42-47.

¹ See Parr, 1930.

² Ventral fins to anal.

³ Pectoral fins to ventrals. The sections here not mentioned in their morphological order, but in the order of their taxonomic importance.

- a. Head less¹ than 10 per cent, depth less than 7 per cent of the total length without caudal fin.

St. elongatus Wood-Mason and Alcock

- b. Head more than 10 but less than 12 per cent, depth more than 8 per cent of total length without caudal fin.

St. valdiviae Brauer

- c. Head more than 12 per cent ("one-eighth"), depth more than 8 per cent of total length without caudal.

St. affinis Günther

- 11 Ventral row of photophores: V-A. 8-12. P-V. 39-51. Less than 80 scales in a longitudinal series.

- a. Head less than 13 per cent of length without caudal, depth about 10 per cent of the same or less.

1. A. 21-24. Scales in a horizontal series 65-67. Ventral row of photophores: P-V. 39-41. V-A. 8-10. A-C.² 17-18.³

St. colubrinus Garman

2. A. 18-19. Scales in a horizontal series about 75. Ventral row of photophores: P-V. 41-45. V-A. 9-12. A-C. 14-15.

St. atriventer Garman

See below

3. A. 21-22. Scales in a horizontal series about 73-78. Ventral row of photophores: P-V. 46-51. V-A. 10-13. A-C. 15-18.

- x. Barbel with a thick, spindle-shaped stem, and only two tentacles at the end of the bulb.

St. fusus Beebe 1929, p. 7, fig. 1b

¹ In their description Wood-Mason and Alcock (1891, p. 129) give the length of the head as one-tenth of the total without caudal, when "measured from the tip of the mandible," stating later (p. 130) that "the widely-distensible mandible projects much beyond the upper jaw." The length of the head measured from the snout alone, as now customary, must therefore have been considerably less than 10 per cent of the total without caudal in their specimen.

² Origin of anal fin to end of the series (base of caudal).

³ *Fide* Ege 1918, p. 24.

- xx. Barbel with a slender stem and three tentacles from the end of the bulb.

St. boa Risso

SYN.: *St. boa* (Risso) and *St. ferox* (Reinhardt) Ege 1918¹.

St. bonapartei Fowler 1911, p. 556²

?*St. elongatus atlanticus* Pappenheim 1914, p. 169³

- b. Head nearly 16.6 per cent ("nearly 6 in length"), depth of body about 11 per cent of length without caudal. A. 23-24. Ventral row of photophores (according to the figure, Garman 1899, pl. 56, fig. 5): P-V. 39. V-A. 9 (P-A. 48 according to the text).

St. hexagonatus Garman

- III. Ventral row of photophores: V-A. 12-13. P-V. 33-35. Head about 11-12.5 per cent, depth 10-11 per cent of length without caudal. A. 19-20.

St. brevibarbatus Ege 1918 (p. 22)

- IV. Ventral row of photophores: V-A. 14. P-V. 54. About 88 scales in a horizontal series. A. 18. Head about 10.7, depth about 8 per cent of length without caudal.

St. gracilis Garman⁴

¹ It has been adequately shown by the investigations of various ichthyologists (Schmidt, Hubbs, and others) during recent years that minor variations in metameric characters need not be of a genotypic nature, but are, on the contrary, quite commonly found as mere phenotypic expressions of the direct effect of variations in the physical factors of the environment, especially the temperature. A differentiation of two separate forms merely on the basis of minor difference in the averages of their metameric characters, as attempted by Ege for *Stomias boa* and *St. ferox*, is therefore of very questionable taxonomic value, when the forms compared also occupy entirely separate ranges of distribution, with different physical conditions in each. While the established differences are very interesting from an ecological point of view, it would, for taxonomic purposes, be entirely inadvisable to consider them as of more than subspecific significance, if not merely as geographical variations.

² *Fide* Senna: *Monitore Zool. Ital.*, Vol. 28, p. 189.

³ The numbers of photophores in the ventral row recorded by Pappenheim for his new subspecies ("variety"), viz.: P-V. 48, V-A. 11, immediately set it apart from *St. elongatus* Wood-Mason and Alcock and brings it into close relationship with *St. boa*, from which it would only seem differentiable by its somewhat smaller depth of body, which may possibly be due to shrinkage or to other features of preservation, but not by any other significant character mentioned in the description. The present author is therefore inclined to believe that *St. elongatus atlanticus* Pappenheim may actually prove to be entirely identical with *St. boa*.

⁴ Name introduced by Garman (1899, p. 274) for the antarctic specimen referred by Günther (Rep. Sci. Res. "Challenger," Vol. XXII, p. 204) to *Stomias boa*.

B. Premaxillary teeth more numerous and conspicuously smaller than those of the dentaries.

St. nebulosus Alcock

***Stomias atriventer* Garman**

1 specimen, No. 2665 B. O. C. May 28, 1926. 24° 07' N. 108° 40' W. 286 fathoms.

2 specimens, No. 2666 B. O. C. May 29, 1926. 20° 48' 15" N. 106° 11' 50" W. 540 fathoms cable out.

5 specimens, No. 2667 B. O. C. Pacific 1926. No data.

The above listed specimens all agree with the original description within the limits of variation indicated in the key, and it may furthermore be mentioned that their labels, in so far as any are found, show the localities of capture to be practically identical with the type locality of the species (25° 26' 15" N. 109° 48' W., Garman 1899, p. 278). As a contribution to our knowledge of the individual variations within the species the following table of counts and measurements is rendered.

COUNTS AND MEASUREMENTS OF *Stomias atriventer* Garman

Length without caudal fin in mm.		135	130	128	122	117	111	97	92
Depth of body	In percent	7.0	7.7	7.1	7.8	8.1	7.5	7.0	7.6
Length of head	of total	10.4	11.1	11.3	11.5	—	11.3	11.3	10.4
Diameter of eye	length	2.5	3.2	1.8	2.5	2.4	2.3	2.6	2.0
Snout to V	without	72.0	71.0	70.0	74.0	71.0	73.0	71.0	72.0
Vent to base C	caudal fin	14.5	14.0	14.8	14.5	13.7	14.8	15.5	14.7
Ventral row	Isthmus to P	—	11	11	—	11	11	11	11
of	P-V	—	41	41	—	42	45	42	42
photo-	V-A	—	12	11	—	10	9	10	11
phores	A-C	—	14	14	—	15	14	15	14
D		19	15	18	17	18	18	16	18
A		18	18	19	19	18	19	18	19

The species is obviously very close to *Stomias boa*, differing only by the somewhat lower numbers of anal fin rays and photophores. As far as our present knowledge goes, however, these are total differences not differences in point of average values only, and one would therefore seem justified in, at least provisionally, maintaining *St. atriventer* and *St. boa* as entirely separate species until a complete analysis of individual variations in both forms over their entire ranges of distribution may establish whether the remarks made in footnote 1 on p. 9, concerning *St. boa* and *St. ferox*, should, or should not apply also in the case of *St. boa* and *St. atriventer*. The number of scales in a horizontal series in the best preserved specimen has been estimated as about 75.

Suborder HETEROPHOTODERMI¹

Family GONOSTOMATIDAE

Genus *Cyclothone* Goode and Bean*Cyclothone acclinidens* Garman

3 specimens, No. 2677 B. O. C. April 17, 1926. N. 22° 50' 20". W. 109° 48' 15". 525 fathoms.

The sample from the above recorded locality contains three specimens which can be identified by their dentition as *C. acclinidens*, in addition to several badly twisted, torn or shrunk specimens probably of the same species but not directly identifiable.

Genus *Vinciguerria* Jordan and Evermann*Vinciguerria lucetia* Garman

Maurolicus lucetius Garman 1899, p. 242, Plate J, fig. 2.

1 specimen No. 2639 B. O. C. May 28, 1926. N. 24° 30'. W. 108° 55'. 100 fathoms.

2 specimens No. 2643 B. O. C. May 28, 1926. N. 24° 07'? W. 108° 40'. 286 fathoms.

3 specimens No. 2642 B. O. C. May 29, 1926. N. 20° 48' 15". W. 106° 11' 50'. 540 fathoms cable out.

20 specimens No. 2641 B. O. C. May 31, 1926. N. 16° 14'. W. 99° 36' 30". 1800 fathoms depth to bottom. 625 fathoms cable out.

27 specimens No. 2640 B. O. C. June 1, 1926. N. 14° 30' 30". W. 96° 14'. 2100 fathoms depth to bottom. 625 fathoms cable out.

21 specimens No. 2638 B. O. C. June 3, 1926. N. 11° 05'. W. 89° 20' 45". 2000 fathoms depth to bottom. 300 fathoms cable out.

Obviously a very abundant species in the region explored.

Genus *Diplophos* Günther

Diplophos Günther 1873, p. 101.

Manducus Goode and Bean 1895, p. 514.

Lychnopoles Garman 1899, p. 244.

When the various species previously referred to the three genera listed in the above synonymy (more recently reduced by Norman 1930, p. 270, to the two genera *Diplophos* and *Manducus*) are arranged in a comparative tabulation of their characters, as printed on the following pages, they will be seen to form a comparatively complete and continuous series of intergradations from the relatively short and stout *D. corythaeolus*, with few anal rays, to the slender and many-rayed species *D. taenia*, *pacificus* and *proximus*, through the intermediate

¹ See Parr, 1930.

forms of *D. argenteolus* and *D. maderensis*. In view of this fact it hardly seems necessary, or combined with any special advantage, to make any arbitrary generic subdivision at all within the group of species here considered. For this reason only one single genus has been recognized in the present report.

Species		<i>D. pacificus</i> Gthr.	<i>D. taenia</i> Gthr. ¹	<i>D. proximus</i> n. sp.
Total length without caudal fin in mm.		37	59	82
Greatest depth	In per cent of total length without caudal fin, when not otherwise speci- fied	10.0 ("one-tenth")	10.0	10.5
Length of head		20.0 ("one-fifth")	17.0	16.5
Length of snout		"Thrice as long as eye"	5.1	4.5
Diameter of eye		2.5-3.0 ("one-seventh or one-eighth" of head)	3.4	3.5
Interorbital width			3.4	3.0
Maxillary Snout to V.			— 38.0	11.5 37.0
Snout to D.			47.0	48.0
Snout to A.			51.0	50.0
Rays in dorsal fin		12	11	10
Rays in anal fin		53	61	58
Ventral row of luminous organs	Isthmus to pectorals		17-21	16
	Pectorals to ventrals	23? ³	26-28	25
	Ventrals to anal	11? ³	16-17	13
	Origin of anal to end of series ²	51? ³	43-47	41

¹ After Brauer 1906, pp. 89-91.

² Not including the two isolated organs at the base of caudal fin.

³ According to the illustration rendered by Günther 1889, pl. IV, fig. B.

⁴ The proportions of this species have been taken from the original illustration, the authors specifically referring to their figure for this purpose (Jespersen and Taaning 1919, p. 224 and pl. XVII, fig. 15).

Diplophos corythaeolus Alcock 1898 is a rather obscure and very inadequately described species, for which no photophore-counts have been recorded. If it does indeed belong to the genus *Diplophos* it would, however, seem quite distinct from the other species by some of its proportions and by the low number of anal fin-rays.

The synonymies given in the following key do not pretend to list fully all records of the various species, but merely to give reference to all original descriptions and to such subsequent accounts and illustrations as have been found useful for the identification of the various forms.

<i>D. minutus</i> Jesp. & Taan. ⁴	<i>D. maderensis</i> Johns. ⁸	<i>D. moorei</i> Welsh ¹⁰	<i>D. argenteolus</i> Garm. ⁹	<i>D. corythaeolus</i> Alc.
21? ⁶	135	39	89-149	101 ⁷
16.0	14.5	12.7	14-15	16.5-20.0 (one-fifth to one-sixth)
23.5	20.0	19.1	21-22	Ab. 25.0 ("one-fourth")
6.0	"a little longer than eye"	3.9	5.1-5.9	"Hardly longer than eye"
3.5	4.0	2.8	3.9-4.7	Ab. 6.0 ("not quite" one-fourth of head)
—	a little more than eye	3.3	4.7-5.1	"Eyes not quite a diameter apart"
15.5		12.5	17-18	} <i>D. slightly nearer to the snout than to base of C.; an eye-length behind the ventrals</i>
46.0		42.0	39-42	
51.0	<i>D. equidistant from eye and base of C.</i>	50.0	56-57	
62.0		57.0	58-59	
10-12	12	12	14-16	About 11
37-39	36?	38	26-29	About 24
} ³⁰	11	13	12	
	19	17	11	
	13	12	9	
	28	29	19-20	

⁵ 21 mm. being recorded as the size of the largest specimen in the type-material.

⁶ According to the illustration.

⁷ 101 mm. (5 inches) being given as the size of the largest specimen in the type material.

⁸ According to Norman 1930, p. 204.

⁹ See page 16.

¹⁰ Identical with *D. maderensis*.

Key to the genus *Diplophos*

- A. Head large, one-fourth of the length without caudal. Eyes also large, almost one-fourth of the head and nearly equal to the length of the snout. Only about 24 anal rays.

D. corythaeolus Alcock 1898, p. 147

B. Head less than one-fourth of length without caudal. Eyes only about one-fifth of the head, or less; always considerably shorter than snout. About 26-61 anal rays.

I. About 26-29 anal, and 14-16 dorsal rays. Ventral row of photophores: Isthmus to P. 12. P-V. 11. V-A. 9. A-C. 19-20.

D. argenteolus Garman

SYN.: *Lychnoptes argenteolus* Garman 1899, p. 244 and plate LIII, fig. 4.

II. About 37-39 anal, and 10-12 dorsal rays. Ventral row of photophores: Isthmus to P. 12-13. P-V. 17-18. V-A. 12-13. A-C. 28-30. Premaxillaries with marked canines.

D. maderensis (Johnson) fide Norman 1930

SYN.: *Gonostoma maderense* Johnson 1890, Proc. Zool. Soc., p. 458.

Manducus maderensis Goode and Bean 1895, p. 515.

Manducus maderensis Norman 1930, p. 294, fig. 8.

Diplophos minutus Jespersen and Taaning 1919, p. 224, plate XVII, fig. 15.

Diplophos moorei Welsh 1923, p. 1, fig. 1.

III. More than 50 rays in anal fin.

a. Eyes small, only about one-seventh to one-eighth of the length of head and one-third of the snout. Only about 53 anal rays.

D. pacificus Günther 1889, p. 33 and plate IV, fig. B

b. Eyes larger, about one-fifth of the length of head and two-thirds of the length of snout. About 58-61 rays in anal fin.

1. Ventral row of photophores: isthmus to P. 17-21. P-V. 26-28. V-A. 16-17. A-C. 43-47.

D. taenia Günther 1873, p. 104

SYN.: *D. taenia* Günther 1889, p. 32 and plate IV, fig. C.

D. taenia Lütken 1892, p. 278 and plate II, figs. 1-3 (exquisite illustrations).

D. taenia Goode and Bean 1895, p. 104, nec. fig. 126, plate XXXIV (*D. pacificus* Gthr.)

D. taenia Brauer 1906, p. 89 and fig. 36.

2. Ventral row of photophores: isthmus to P. 16. P-V. 25. V-A. 13. A-C. 41.

D. proximus, n. sp.

***D. proximus*, n. sp.**

1 specimen No. 2676 B. O. C. May 28, 1926. 24° 07' N. 108° 40' W. 286 fathoms.

Due to the fact that the differences between the specimen now at hand and the descriptions of *D. taenia* do not merely represent a simple, although total,

difference in metameric characters, but also a difference in metameric proportions between the various sections of the ventral row of photophores, the absolute difference being greatest where the smallest total number of organs are found (V-A), the author feels quite justified in describing the specimen as the type of a distinct species.

It is unfortunate that the ultimate end of the tail has become lost in the type by obvious violence, but the specimen is otherwise in a perfect condition from the snout to somewhat beyond the end of the anal fin; and since the free caudal peduncle is always extremely short in the genus here considered, the proportions given in the table on page 12 may be regarded as quite reliable on the basis of an estimated length without caudal fin of 82 mm. of which 79.5 mm. are measured in the preserved specimen. The counts and measurements rendered in the table need not be further discussed here, but the following features can be added.

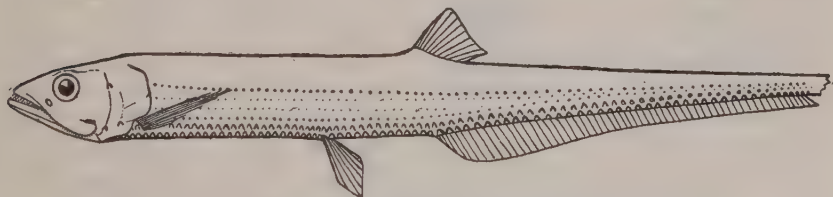


Figure 4. *Diplophos proximus* n. sp.

There is one rounded luminous organ below and immediately in front of each eye. 11 organs on each branchiostegal membrane. 3 in a small linear group on each cheek under the posterior end of the maxillary. Three, somewhat larger ones distributed over the rest of the cheek in the following manner: one at the lower end and one near the top of the preoperculum, plus one in the corner between pre-, sub- and inter-operculum. On the sides of the body the next row above the ventral series shows the following counts: 2 in front of the pectoral base; 25 from P. to V.; 14 from V. to A.; and from the origin of anal fin to the end of the series about 36-37, the 24 most anterior ones well developed and conspicuous, the following ones small and circular, less conspicuous, and those beyond the 37th, which have not been counted, almost rudimentary. About 80 small circular organs in the row following the lateral line. All scales below the lateral line with a small rounded photophore each, when not otherwise mentioned (as in the case of the two most ventral series which carry the two rows of larger luminous organs). The last organ counted in the ventral row of photophores (see the table on page 12) is dotlike and situated immediately beyond the end of the anal fin.

Branchiostegals 12. Gillrakers in lower half of first arch 9, fairly long. P. 9. V. 8. D. $10\frac{1}{2}$. A. 58.

Length of pectoral fins about 12.5, length of ventrals about 8.5 per cent of total without caudal.

About 85 scales in a horizontal and 10 in a transverse series.

Diplophos argenteolus Garman

Lychnopoles argenteolus Garman 1899, p. 242, pl. 53, fig. 4.

The writer has had opportunity to investigate the type-sample of this species in the Museum of Comparative Zoology at Harvard University, and has taken the following measurements of four of the specimens:

Length without caudal fin in mm.		149	127	118	89
Greatest depth		15	15	14	14
Length of head	In	22	22	21	22
Length of snout	per cent	5.5	5.9	5.1	5.6
Diameter of eye	of	4.0	3.9	4.1	4.7
Interorbital width	the length	4.7	5.0	4.7	5.1
Length of maxillary	without	17	17	16	18
Snout to V	caudal	40	40	39	42
Snout to D	fin	57	57	56	57
Snout to A		58	58	59	59

The proportions of the species are characterized by the comparatively wide interorbital space, long maxillary, and posterior insertion of the dorsal fin, in all of which features the species seems to represent a well marked extreme within the genus (see comparative tabulation on page 13). The origin of anal fin is only a short distance behind that of the dorsal fin, although the difference is always distinct. The body is moderately deep (for the genus) and the number of anal fin rays is low, as are also the numbers of luminous organs. The counts of the latter entered in the table on page 13 have been obtained by the writer in the manner that the section from isthmus to pectoral fins has been counted to, and including, the space below the bases of the latter, the section from pectorals to the ventral fins starting only at the posterior end of the pectoral fin bases. The last two organs at the base of the caudal fin have not been included in the counts from origin of anal fin to the end of the series.

The teeth in the premaxillaries are differentiated into two distinctly different sizes, of which the larger ones might well be called canines (see Norman 1930, p. 294, "Synopsis of the species") although they are not as large as shown in the illustration of *D. maderensis* (Norman 1930, op. cit., fig. 8, p. 294) and more numerous, there being about 10 to 15 of these enlarged teeth in each premaxillary.

The lower jaw is very prominent, the profile of its symphysis forming a continuation of the dorsal profile of the head.

Family **STERNOPTYCHIDAE**Genus **Argyropelecus** Cocco**Argyropelecus lychnus** Garman

Argyropelecus lychnus Garman 1899, p. 234, pl. J, fig. 1.

?*Argyropelecus olfersii* (Cuvier 1829) Norman 1930, p. 304, fig. 12 (with synonymy)?

2 specimens, No. 2709 B. O. C. May 28, 1926. 24° 07' N. 108° 40' W. 286 fathoms.

1 specimen, No. 2707 B. O. C. June 1, 1926. 14° 30' 30" N. 96° 14' W. 2100 fathoms depth to bottom. 625 fathoms cable out.

11 specimens, No. 2708 B. O. C. June 3, 1926. 11° 05' N. 89° 20' 45" W. 2000 fathoms depth to bottom. 300 fathoms cable out.

1 specimen, No. 2710 B. O. C. Pacific 1926. No data.

While the identity of the above recorded samples with the form described by Garman as *A. lychnus* has been established by direct comparison with the types of the latter species in the Museum of Comparative Zoology of Harvard University, the author has not had opportunity to reach any definite conclusion as to whether this form should be considered specifically identical with *A. olfersii* from the Atlantic or not, as suggested by European authors, and has therefore not felt entitled to apply the latter designation to the material now at hand.

In regard to the relative depth of the body, *A. lychnus* would seem to be in perfect agreement with *A. olfersii* as shown by the following list of measurements in which the length of each specimen in millimeters (exclusive of the caudal fin) is given in ordinary (Roman) figures followed by the relative depth of body, in per cent of the said measurement, in italics between brackets: 15(73); 21(71); 30(67); 32(66); 32(69); 34(68); 34(70); 35(67); 35(71); 38(67); 39(64); 40(63); 42(67); 44(66); 48(68).

The shape of the abdominal spines is apparently quite characteristic of the species at hand, but has not been described or figured in sufficient detail for *A. olfersii* to make a reliable comparison possible on this point. All specimens show a set of two abdominal spines, one directed obliquely downward and backward, and one about vertically downward. The latter spine apparently undergoes a very characteristic change with growth, as shown in the accompanying outline drawings (fig. 5). In the smallest specimen the said spine is still straight, slender and simple. At 21 mm. length without caudal fin a thin lamella-like median expansion has developed in front on the lower third of the spine, while the core of the spine itself still remains straight. In the larger specimens this anterior expansion is still further developed and the distal end of the core of the spine itself has received a sharp, kneelike flexure forward. This characteristic feature of the anterior abdominal spine can be seen in all specimens 30 mm. long or more (exclusive of caudal fin) and may therefore in all probability be regarded

as a taxonomically significant feature about which information is lacking for *A. olfersii*.

Attention should finally be called to the fact that the supra-anal photophores of all adult specimens (30 mm. and larger) are separated from the caudal organs by a space which is not only shorter than the length of the supra-anal series but also very conspicuously shorter than the length of the caudal series (only $\frac{1}{2}$ to $\frac{3}{4}$ of the latter), a feature which is in considerable disagreement with Norman's figure of an *A. olfersii* about 30 mm. long (Norman 1930, fig. 12, p. 304).

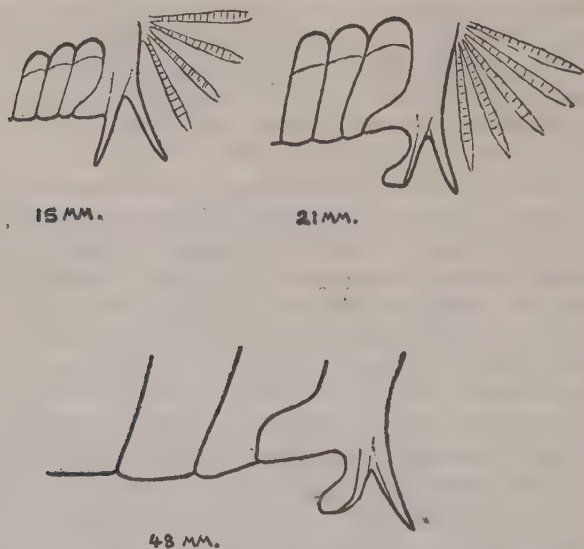


Figure 5. Abdominal spines of *Argyropelecus lychnus* in specimens of various sizes. Total length without caudal fin given below each drawing.

Suborder GYMNOTODERMI

Family **MELANOSTOMIATIDAE**

Genus **Bathophilus** Giglioli

Bathophilus filifer Garman

Dactylostomias filifer Garman 1899, p. 279.

7 specimens, No. 2650 B. O. C. May 31, 1926. 16° 14' N. 99° 36' 30" W.
625 fathoms cable out. Depth to bottom 1800 fathoms.

7 specimens, No. 2651 B. O. C. Pacific 1926. No data.

Genus **Idiacanthus** Peters

Idiacanthus panamensis Regan and Trewavas

4 specimens, No. 2662 B. O. C. 16° 14' N. 99° 36' 30" W. 625 fathoms
cable out. Depth to bottom 1800 fathoms. May 31, 1926.

3 specimens, No. 2661 B. O. C. 11° 05' N. 89° 20' 45" W. 300 fathoms cable out. Depth to bottom 2000 fathoms. June 3, 1926.

7 specimens, No. 2664 B. O. C. Pacific 1926. No data. Good or fair condition.

?6 specimens, No. 2663 B. O. C. Pacific 1926. No data. Poor condition.

All the above recorded samples, insofar as they are in a sufficiently good state of preservation, show a perfect concordance with the description of *Idiacanthus panamensis* rendered by Regan and Trewavas (1930, p. 131 and plate VI, fig. 2). It may be mentioned, however, that the range of variations in regard to the spatial relationship between dorsal and ventral fins is somewhat wider than previously recorded, the ventrals being in the present material found below the third to the tenth dorsal ray instead of only below the fifth to the tenth ray. The position of the ventrals relative to snout and origin of anal fin is, on the other hand, quite typical and rather sharply defined as shown by the following measurements, which may serve for a more accurate comparison with other species:

Length without caudal in mm.	Snout to ventral fins in per cent of length without caudal	Snout to anal fin in per cent of length without caudal
184	36	69
182	37	70
176	35	71
176	35	70
171	36	73
168	37	71
166	37	70
165	37	70
153	35	71
143	38	72
127	35	70
82	36	70

It will be noticed that the ventrals are placed in a very nearly (or even entirely) equidistant position between the snout and the origin of anal fin.

INIOMI

Family **Sudidae**

Genus **Paralepis** Cuvier¹

Paralepis pacificus n. sp.

2 specimens, No. 2654 (Type) and 2655. N. 20° 48' 15". W. 106° 11' 50". 540 fathoms cable out. May 29, 1926.

¹ The genus *Paralepis*, as here understood, also embraces *Lestidium* Gilbert and *Lestidiops* Hubbs. The reasons for making this combination are considered in a separate article (Copeia 1931, in the press).

This species, of which two specimens are now at hand, is distinct from all other species of *Paralepis* (including *Lestidium* and *Lestidiops*) by the relative positions of its dorsal and ventral fins. In dentition the new form agrees with group II, in the key to the Atlantic species of *Paralepis* rendered by Ege (1930, p. 8). Within this group *P. pacificus* differs from *P. atlanticus* (Borodin)¹ by having the ventral fins inserted conspicuously in advance of the dorsal, while it is equally distinct from all the remaining species of the same group by the fact that the horizontal distance between the bases of the anterior ventral and dorsal rays is only about three per cent of the total length without caudal fin, or less, instead of more than six (6-13, *P. intermedius* included) per cent of the latter measurement. *P. pacificus* may, further, in a similar manner be distinguished from *P.* ("*Lestidium*") *nudum* Gilbert and *P.* ("*Lestidiops*") *sphyraenopsis* Hubbs by the fact that the ventrals are also in both of these species inserted more than seven (7-12) per cent of the total length without caudal fin in advance of the dorsal. *P. japonicus* Tanaka differs by having 42-49 anal rays.

TABLE OF MEASUREMENTS OF *Paralepis pacificus*

Specimen No.		2654 TYPE	2655
Length without caudal fin in mm.		164	78
Greatest depth		6.7	5.8
Least depth of caudal peduncle		2.3	2.5
Length of head		20.1	21.0
Diameter of eye		3.4	2.5
Length of snout	In	9.8	11.5
Snout to nostril	per	7.5	8.3
Interorbital width	cent	2.6	2.5
Length of maxillary	of	8.8	8.5
Length of lower jaw	the	12.5	13.0
Snout to V.	length	58.0	59.0
Snout to D.	without	61.0	61.0
Snout to anus	caudal	64.6	66.5
Snout to A.	fin	77.0	78.0
Base of A.		17.5	18.0
Length of C. (lower lobe)		7.0	7.8
Length of P.		9.5	—

It will be noticed from the accompanying table of measurements that the eyes of the smaller specimen are also relatively considerably smaller than those of the larger one, while the agreement in all other respects is so perfect that the author has no great hesitation at all in referring both specimens to the same species.

¹ *P. thermophilus* Ege. See Parr: Copeia 1931, in press.

This apparent inversion of the rule more commonly found valid among fishes that there is a gradual decrease in the relative dimension of the eyes with the growth of the specimen, may be correlated with the fact that the species here considered is typically a rather large-eyed form, the true significance of the above-mentioned empirical rule perhaps being that there is generally during ontogeny, a gradual change from some "neutral" size of the eyes towards the size characteristic of the adults of each particular species, the dimension of the eyes in the adult of not especially large-eyed forms being, in most cases, smaller or at least not larger than the "neutral" juvenile size for fishes of their general type and relationships, while the inverse is occasionally true in particularly large-eyed forms, such as the one here considered.

The ventrals are inserted immediately in advance of the dorsal fin, so that the posterior corners of their axils barely touch the vertical from the anterior end of the dorsal fin base. Both specimens are perfectly concordant in this respect. The maxillaries do not extend to the eyes, while the mandibles reach to below

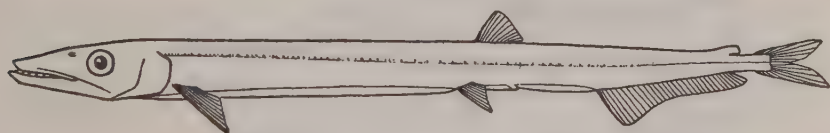


Figure 6. *Paralepis pacificus* n. sp.

their centres. The other proportions of the species here considered are sufficiently indicated in the above table of measurements and should not require any further discussion here.

84 vertebrae, the up-turned centra at the end being counted as 1 only.

D. 10 (or $9\frac{1}{2}$, the two last rays being completely separated but inserted upon the same pterygiophore). A 30 in the type, 28 in the smaller specimen. P. 11. V. 9. Ventral carina strongly developed.

The lateral line shows about 63–68 segments (hidden scales?). Two pores above and two below each segment.

Each branch of the lower jaw with one or two very small teeth anteriorly immediately followed by one or two larger fangs. Behind this anterior group the type specimen shows a series of 9–10 fangs, partly arranged in pairs or accompanied by a shorter more strongly curved exterior tooth (see figure 7) each. The largest of these fangs reach a length of about one-ninth of the length of the snout. In the co-type the number of fangs in this posterior series in each branch of the lower jaw is only 6–7, also accompanied by shorter exterior teeth. The premaxillaries of both specimens have three relatively erect teeth anteriorly, but in the juvenile co-type these are only followed by 20–23 smaller decurved teeth occupying the rest of the jaw, while in the type there are about 60–65 of these smaller teeth. Each palatine with a double row of teeth arranged in

pairs. 5 wideset pairs of large fangs anteriorly, with the inner tooth of each pair longer and straighter than the outer, followed by a posterior series of about 7-10 pairs of small close-set teeth in the type. Co-type essentially in agreement with the type, but posterior palatine dentition still relatively wide-set.

The color of the type is now strongly faded but the anal and caudal fins and the ultimate portion of the tail itself is considerably darker than the rest of the fish, which is quite pale. In the smaller specimen the black pigmentation of the peritoneum can be seen through the body wall and is found to be divided into eight sections on each side, separated by narrow, pale bands.

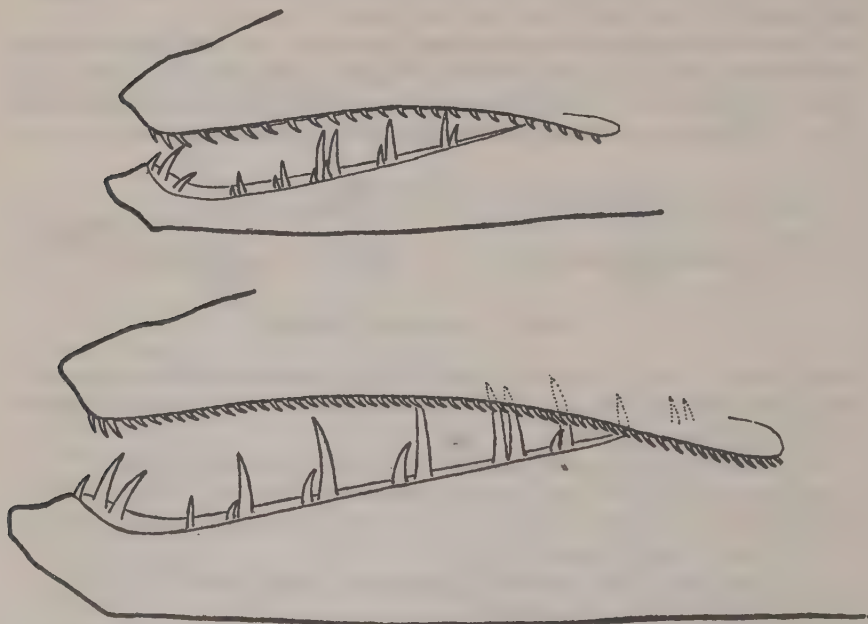


Figure 7. Dentition of *Paralepis pacificus* n. sp. Co-type above, type below.

Family **MYCTOPHIDAE**

Genus **Myctophum** Rafinesque

Myctophum pterotum (Alcock)

Myctophum pterotum Norman 1929 a, p. 512 and fig. 2.

1 specimen, No. 2678 B. O. C. April 17, 1926. N. 22° 50' 20". W. 109° 48' 15". 525 fathoms.

1 specimen, No. 2649 B. O. C. May 31, 1926. N. 16° 14'. W. 99° 36' 30". 1800 fathoms depth to bottom. 625 fathoms cable out.

Here identified according to the description and figure rendered by Norman (loc. cit.). 6 + 4 A O were counted in one specimen, 7 + 3 in the other, both being symmetrical.

Myctophum laternatum Garman (1899, p. 267 and pl. 56, fig. 1)

1 specimen, No. 2647 B. O. C. May 31, 1926. N. 16° 14'. W. 99° 36' 30".
1800 fathoms depth to bottom. 625 fathoms cable out.

1 specimen, No. 2648 B. O. C. June 3, 1926. N. 11° 05'. W. 89° 20' 45".
2000 fathoms depth to bottom. 300 fathoms cable out.

In addition to the above recorded two specimens, the author has also had opportunity to investigate the type sample in the Museum of Comparative Zoology at Harvard University, and is therefore in position to give a redescription and figure of the species from authenticated material.

The following measurements are taken from the two best specimens of the seven included in the type sample (No. 28492 M. C. Z.)

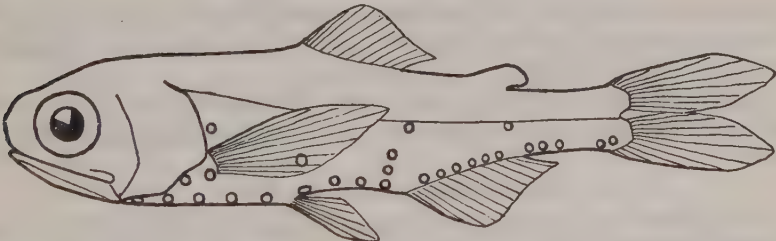


Figure 8. *Myctophum laternatum*.

MEASUREMENTS OF *Myctophum laternatum* Garman

Length without caudal fin in mm.		24	25
Length of head	In per cent of the total length without caudal fin	31	32
Depth of body		25	25
Diameter of eye		9.5	10.8
Lower jaw		21	20
Snout to D.		50	48
Snout to V.		46	44
Snout to A.		62	62

PLO slightly nearer to P than to the lateral line, or about mid-way between these points. 2 PVO, the upper at the lower end of the pectoral fin base, the lower somewhat lower and far in advance, so that the line through the two organs (PVO) is pointing in a direction towards or slightly above the most anterior PO. 5 PO, equally spaced and all on the same level. VLO approximately on the level of the upper end of the base of pectoral fin, about mid-way between lateral line and ventral fins, or somewhat nearer to the latter. 4 VO, the elevation of the

second VO scarcely appreciable. 3 SAO, in a slightly convex series, the line through the first (lower) and second organs passing somewhat in front of the upper organ and also distinctly in advance of the centre of the fourth VO. Fourth VO and first and second SAO equally spaced; upper SAO farther apart, at the lateral line. AO all on the same level, and present in the following combinations (the table includes the counts of the legible specimens in the type sample as well as the two specimens of the Bingham Oceanographic Collection).

AO		posteriores		
		2	3	4
anteriores	6	2	11	1
	7	1	2	

1 Pol, at the lateral line. AO posteriores entirely behind the base of anal fin. 2 Prc, close together at the ventral portion of the base of caudal fin, the second organ only very slightly higher than the first.

Pectorals long, reaching fully to the anal fin. The proportions have otherwise been sufficiently dealt with by Garman and in the preceding table of measurements.

Genus *Lampanyctus* Bonaparte

Three distinct species of *Lampanyctus* are contained in the samples of deep-sea fishes from the Pacific collected during 1926, and have all been found to possess a luminous dot on each shoulder, in the well-preserved specimens, without also possessing any photophores on the cheeks. By this combination of characters, they may thus be referred to the very heterogeneous *macropterus* group, which is here merely being provisionally maintained for practical purposes of identification. Since one of these species has been found to be entirely new to science and another not previously known to possess a shoulder-dot, this would increase the number of species thus characterized from two (Parr, 1928, p. 88) to four, and a revision of the group would seem to be in place. In the course of that endeavor, the writer has become convinced that Brauer (1906, p. 249) must have confused at least two, perhaps even more species, under the heading of *L. macropterus*, and that the Atlantic material previously referred by the writer (Parr, 1928, p. 110) to *L. macropterus* cannot be considered identical with the specimen shown in Brauer's original illustration and description of the species (Brauer, 1904, fig. 5, p. 381, and p. 404).

Before proceeding with the analysis of these species, it is necessary to point out that, due to its often diminutive size and the ease with which it becomes lost in the handling of the specimens, the presence or absence of a shoulder-dot alone has proved to give very unreliable information about the identity, except

of the most perfectly preserved material.¹ It is, therefore, highly desirable that all species found, on occasion, to possess a luminous organ on the shoulder, should not only be differentiated in their descriptions from the other forms in which similar organs have been observed, but also from all other species with which it might be confused when the shoulder-dot is lost. In future keys, such species should, therefore, for practical purposes, be identified in their proper positions both on the assumption that this organ may and that it may not be discernible in the material at hand.

On the following pages the author will try to differentiate each species on both assumptions, while a complete key can only be given on the basis of the shoulder organ being present and discernible.

KEY TO THE SPECIES OF *LAMPANYCTUS* WITH ONE LUMINOUS ORGAN
ON EACH SHOULDER, BUT NONE ON THE CHEEKS, WITH THE
FOURTH PO ELEVATED, AND WITH THE LUMINOUS
SCALES CONFINED TO THE CAUDAL PE-
DUNCLE AND ADIPOSE FIN

A. Pectoral fins long and well developed. Only 4 VO, of which only one is elevated. At least the first of the AO posteriores at the base of anal fin.

I. Second VO elevated and advanced so as to become situated above or in front of the first VO. AO confluent with Prc. The two first organs in the posterior section of the anal series (AO post. 1-2) situated at the base of anal fin. AO 4-6 + 8-10.

L. omostigma Gilbert

II. Second VO behind the first, more or less elevated.

a. Second VO greatly elevated. AO posterior confluent with the Prc. Both first and second organs of the AO posteriores situated at the base of anal fin. Only 5-7 luminous scales below the caudal peduncle.

L. macropterus Brauer

b. Second VO only slightly elevated. Prc distinct from the AO posteriores. 8-10 luminous scales below the caudal peduncle. Only the first of the AO posteriors situated at the base of anal fin.

L. nobilis Taaning

B. Pectoral fins short or entirely rudimentary. 4 or 5 VO. AO posteriores entirely behind anal fin.

I. 5 VO. The second VO elevated and advanced so as to become situated anteriorly to the first VO immediately above the base of ventral fin. Third VO also elevated. VLO at the lateral line.

L. mexicanus Gilbert

¹ The unreliability of the shoulder-dot for taxonomic purposes has already been pointed out by Taaning (1928, p. 51).

- II. Only 4 VO. Second VO scarcely elevated at all and normally placed between the first and third VO. Third VO not elevated. VLO about mid-way between ventrals and lateral line.

L. idostigma n. sp.

Lampanyctus omostigma Gilbert 1908

Lampanyctus omostigma Gilbert 1908, p. 232 and plate 5.

Lampanyctus omostigma Parr 1928, p. 88.

Subspecies **parvicauda** n. subsp.

2 specimens, No. 2681 B. O. C. May 29, 1926. N. 20° 48' 15". W. 106° 11' 50". 540 fathoms cable out.

12 specimens, No. 2682 B. O. C. (TYPE) and 2684 B. O. C. (Cotypes), May 31, 1926. N. 16° 14'. W. 99° 36' 30". 1800 fathoms depth to bottom. 625 fathoms cable out.

10 specimens, No. 2683 B. O. C. June 3, 1926. N. 11° 05'. W. 89° 20' 45". 2000 fathoms depth to bottom. 300 fathoms cable out.

4 specimens, No. 2685 B. O. C. Pacific 1926. No date.

By a comparison with the original description and illustration of the species one may notice the following minor differences in the material now at hand: The distance of the PLO from the lateral line is only about one-third to one-half of its distance from the pectoral fin base, instead of about two-thirds of the latter distance as in the typical form. The origin of anal fin is under the posterior part of the dorsal, but not under its end. There are only 4-6 infracaudal luminous scales, instead of 9 as in the type and cotype of Gilbert's form. These differences may serve to provisionally differentiate a separate new subspecies:

Lampanyctus omostigma parvicauda

which should be elevated to the rank of a species if further collecting fails to produce any intermediate forms. Subspecies *parvicauda* is otherwise perfectly concordant with *L. omostigma omostigma* as will appear from the accompanying illustration and the following description and tables of counts and measurements.

PLO as above described. Lower PVO obliquely below and in front of upper PVO. Fourth PO elevated to a level slightly below that of upper PVO. VLO about one-fourth to two-fifths as far removed from the lateral line as from the ventral fins, the ratio varying with the distension of the belly. 4 VO, the second immediately above the first, very slightly lower than the fourth PO and first SAO. First SAO above the interspace between third and fourth VO. Second SAO very slightly higher than the first, about equidistant from the latter and from the last VO and in an approximately straight oblique line between the latter

and the somewhat farther removed third SAO, which is in contact with the lateral line. The anal organs (AO) are present in the following combinations:

AO		posteriores		
		8	9	10
anteriores	4		10	1
	5	26	11	
	6	1		

First AO anterior lower than the rest of the series. The two first AO posteriores always at the base of the anal fin. Upper Pol at the lateral line. 4 Prc, confluent with the AO posteriores, the third in a straight, oblique line between the second and fourth Prc; the latter immediately above the end of the lateral line.

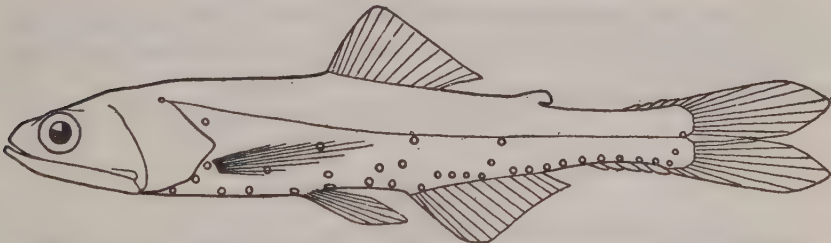


Figure 9. *Lampanyctus omostigma parvicauda* n. subsp.

MEASUREMENTS OF *L. omostigma parvicauda* n. sp.

Length without caudal in mm.		89	73	63	60
Depth of body		18	19	19	17
Length of head		28	31	31	30
Diameter of eye	In	5.5	6.0	6.5	6.0
Length of snout	per cent	4.5	5.5	5.0	5.5
Length of maxillary	of the	19	20	20	20
Length of lower jaw	total	20	21	21	21
Snout to V	length	42	43	43	43
Snout to D	without	48	48	49	48
Snout to A	caudal	57	58	58	58
Base of D	fin	18	17	16	18
Base of A		24	22	22	23
Length of P		21	23	23	21

The various proportions and the general appearance need not be further discussed here, being adequately treated in the drawing and in the table of measurements. D. $13\frac{1}{2}$. A. $17\frac{1}{2}$.

There are 2-4 luminous scales above and only 4-6 below the caudal peduncle, the infracaudal series beginning at the fourth to the sixth AO posterior.

In the absence of a shoulder dot, *L. omostigma* will come under point B, III, a, 2, x in the previously rendered key to the genus *Lampanyctus* (Parr, 1928, p. 83), but could be differentiated from the other three species falling within the same group in the following manner:

From *L. tenuiforme* Brauer (1906, p. 243), by the fact that none of the four VO in Brauer's species is elevated, as well as by other characters.

From *L. festivus* Taaning (1928, p. 67), by the fact that the last three Prc of this latter species never form a straight series, and its first SAO is situated above or anterior to the third VO.

Finally, from *L. macropterus* Brauer and from *L. nobilis* Taaning below, in the manner already shown in the key on the preceding pages of this article.

***Lampanyctus macropterus* Brauer 1904**

Myctophum (*Lampanyctus*) *macropterus* Brauer 1904, p. 404 and fig. 5, p. 381.

Myctophum (*Lampanyctus*) *macropterus* Brauer 1906, p. 249 (partim) and fig. 166 (nec. fig. 167).

Nec. *Lampanyctus macropterus* Parr 1928, p. 110.

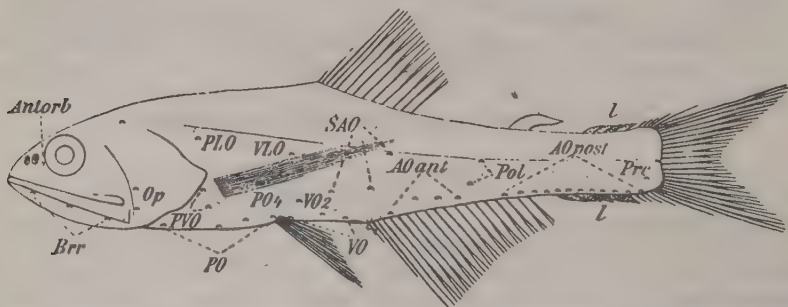


Figure 10. *Lampanyctus macropterus*. After Brauer 1904, fig. 5, p. 381.

Due to the fact, already previously pointed out, that Brauer's later and more detailed description (Brauer, 1906, p. 249) of what he assumed to be a single species referable to his *L. macropterus* seem to be based upon a confusion of several distinct forms, we are now forced to rely solely upon the rather preliminary original description and figure for our information about how the species *L. macropterus*, *sensu stricto*, should properly be defined; and from this information alone, mainly from the figure, the definition rendered in the preceding key

has been obtained. For the reader's convenience a reproduction of Brauer's illustration is rendered herewith.

In the absence of the shoulder dot, *L. macropterus* will also fall under the same point B, III, a, 2, x in the previously rendered key (Parr, 1928, p. 83), as will *L. omostigma*, above, and will, under those circumstances, be differentiable from the three species *L. tenuiforme*, *L. nobilis*, and *L. festivus* by exactly the same characters as already made out for *L. omostigma*. The differentiation of *L. macropterus* from *L. omostigma* and *L. nobilis*, also when the shoulder dot should be lost in all three forms, would still follow in the manner already shown in the key on p. 25.

Lampanyctus nobilis Taaning

Lampanyctus macropterus Parr 1928, p. 110.

The writer is indebted to Dr. Taaning for kindly verifying the identity of the specimen upon which the following description is based with his own species,

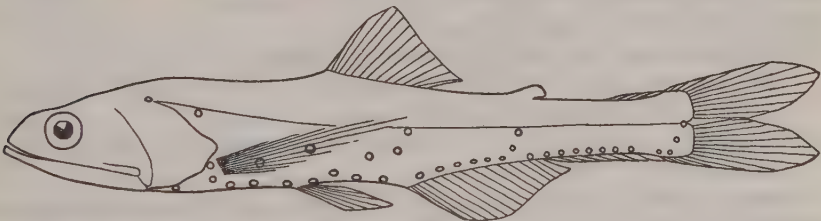


Figure 11. *Lampanyctus nobilis*.

L. nobilis, by comparison of the accompanying diagrammatic drawing with the type material of the latter form.

Shoulder-dot present in well preserved specimens. PLO close to the lateral line, in a straight series with the two PVO, of which the lower is slightly behind the upper. 5 PO, the fourth elevated approximately to the level of the upper PVO. VLO somewhat above midway between the ventral fins and the lateral line, the distance from the latter being approximately two-fifths of the distance from the former. The fourth PO, VLO and upper SAO forming an almost straight series. 4 VO, the second slightly elevated, but about equally spaced between the first and the third VO. 3 SAO, angulate and about equidistant from each other. First SAO above the interspace between third and fourth VO. First and second VO forms a line approximately parallel with that from the VLO to the upper SAO, which is at the lateral line. Second and third SAO are in a straight series with the fourth VO. AO 6 + 8. First AO anterior is only very slightly lower than the rest of the series in the best specimen at hand [always lower according to Taaning (*in litt.*)]. First AO posterior at the base of the anal fin. 2 Pol, the upper at the lateral line. 4 Prc. distinctly separated from

the AO posteriores. Second to fourth Prc in a straight, obliquely ascending series, with the last organ in the end of the lateral line.

The best specimen gave the following measurements: Length without caudal fin 33.5 mm. Proportions in per cent of the length without caudal fin: Depth of body 16. Length of head 31. Diameter of eye 5. Length of snout 6. Maxillary 21. Snout to V. 43. Snout to D. 48. Snout to A. 55. Base of D. 16. Base of A. 21. Length of P. 31.

D. 15, A. $19\frac{1}{2}$. Four supracaudal and eight infracaudal luminous scales, the latter occupying the full length of the free caudal peduncle.

In the absence of the shoulder dot, *L. nobilis* can be identified by its position in the previously rendered key (Parr 1928, p. 84), in which the existence of this organ was not recognized.

Lampanyctus mexicanus Gilbert 1891

Myctophum mexicanum Gilbert 1891, p. 51.

Lampanyctus mexicanus Parr 1929 a, p. 15 (with synonymy).

Myctophum oculeum Garman 1899, p. 260.

Lampanyctus oculeus Parr 1928, p. 85 (with synonymy).

1 specimen, No. 2679 B. O. C. April 17, 1926. N. $22^{\circ} 50' 20''$. W. $109^{\circ} 48' 15''$. 525 fathoms wire out ?.

22 specimens, No. 2680 B. O. C. May 28, 1926. N. $24^{\circ} 07'$. W. $108^{\circ} 40'$. 286 fathoms.

A study of the type sample of *L. oculeus* Garman in the Museum of Comparative Zoology of Harvard University (M. C. Z. No. 28500), together with the quite considerable material now at hand, has convinced the writer that this form cannot be considered specifically distinct from *L. mexicanus* Gilbert, the existing confusion on this point being due to the fact that the VLO has, in all probability, become lost in the type of *L. mexicanus*, the organ previously interpreted as the VLO actually being the elevated and advanced second VO characteristic of *L. oculeus*. If, with this possibility in mind, one compares the accompanying diagram of the species, based upon the material now at hand and verified on the type of *L. oculeus* in regard to the relative position of all organs, with the drawing of the type of *L. mexicanus* previously rendered by the writer (Parr 1929 a, fig. 6, p. 16), one will immediately find a perfect correspondence in the arrangement of all the remaining organs in the latter specimen with that observed in *L. oculeus*. It is unfortunate that the other five specimens of *L. mexicanus*, mentioned in Dr. Gilbert's original description have not been deposited in the U. S. National Museum, but even without seeing these, the author feels quite confident in reducing *L. oculeus* to the synonymy of *L. mexicanus*. This conclusion also gathers a certain support from the fact that all specimens so far recorded under the two designations, as well as the material now at hand, have exclusively been obtained from a rather limited region off the western coast of Central America and Southern North America.

L. mexicanus is distinct from all other species of the genus by the peculiarly advanced position of its second elevated VO (first clearly recognized by Gilbert 1913, p. 102 (*L. oculus*), which is situated in advance of the first VO directly above the base of ventral fin; and is furthermore characterized by having also the third VO elevated to the same level as the second, and situated about mid-way between the first and fourth VO. From the material now at hand, it may finally be added that well-preserved specimens show a small, but unmistakable, shoulder organ.

The following table summarizes the measurements of various specimens, including the types.

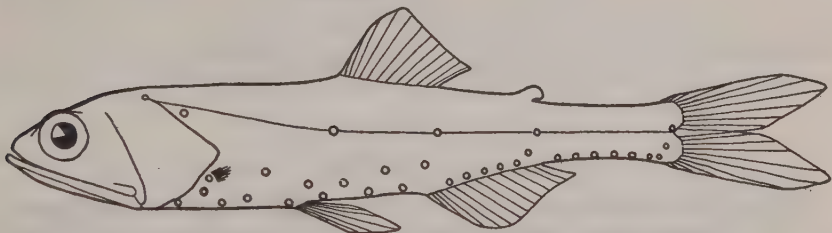


Figure 12. *Lampanyctus mexicanus*.

MEASUREMENTS OF *Lampanyctus mexicanus* Gilbert

Material		No. 2680 B.O.C.			<i>L. oculus</i> Type and Cotype	<i>L. mexicanus</i> Type
Length without caudal fin in mm.		52	49	48	60 58	44
Depth of body		19	19	19	17 17	18
Length of head		31	32	32	30 29	30
Diameter of eye	In	7.5	7.0	8.0	8.5 8.5	6.8
Length of snout	per cent	5	5	5		
Maxillary	of	21	21	21		
Lower jaw	length	22	22	22	20 21	23
Snout to V.	without	45	43	42	42	42
Snout to D.	caudal	50	50	49	49 50	50
Snout to A.	fin.	63	62	58	59 59	60
Base of D.		15	16	17		
Base of A.		17	17	19		

PLO at lateral line. PVO pointing obliquely downward and forward. 5 PO, the fourth elevated approximately to level of upper PVO. VLO at lateral line and rather posterior in position, being situated only a little in advance of the

vertical from third VO. 5 VO, the second and third organ elevated to the same level, which is considerably lower than that of the fourth PO. Second VO in advance of first VO, third VO approximately mid-way between first and fourth VO. 3 SAO, angulate, first SAO above interspace between fourth and fifth VO, distinctly higher than second and third VO, but somewhat lower than second SAO. Second SAO about equidistant from first and third SAO, behind fifth VO. Third SAO at the lateral line; line through second and third VO passing distinctly behind last VO. The AO are found in the following combinations in the material now at hand.

AO		posteriores	
		4	5
anteriores	4		11
	5	5	4

The type of *L. mexicanus* shows 4 + ? (6 or 5, by estimate of lost organs). And the type sample of *L. oculus* 5-6 + 6, 6 + 6 occurring only as an asymmetrical abnormality on one side of one specimen. The total range of variation would thus be AO 4-6 + 4-6, the sum of the two sections varying only between 9 and 12. AO posteriores entirely behind anal fin. 2 Pol, the upper at the lateral line. 4 Pre, usually distinct from the posterior AO by their somewhat smaller size and closer spacing. Third Pre in an approximately straight line upwards and backwards between second and fourth Pre, somewhat closer to the former than to the latter. Last Pre immediately above the end of the lateral line.

The differentiation of *L. mexicanus* from other species of *Lampanyctus*, in the case of the shoulder dot having become lost, has already been discussed on the preceding page.

***Lampanyctus idostigma*, n. sp.**

1 specimen, No. 2687 B. O. C. May 28, 1926. N. 24° 07'. W. 108° 40'. 286 fathoms.

1 specimen, No. 2686 B. O. C. [TYPE]. May 31, 1926. N. 16° 14'. W. 99° 36' 30". Depth to bottom 1800 fathoms. 625 fathoms cable out.

25 specimens, No. 2688 B. O. C. June 3, 1926. N. 11° 05'. W. 89° 20' 45". 2000 fathoms depth to bottom. 300 fathoms cable out.

Measurements of the type specimen: Length without caudal fin 76 mm. Proportions in per cent of the length without caudal fin: Depth of body 14.5. Length of head 29. Diameter of eye 5.2. Length of snout 4.5. Length of maxillary 20. Length of lower jaw 21. Snout to V. 39. Snout to D. 47. Snout to A. 55. Base of D. 16. Base of A. 24.

The general appearance can be seen from the accompanying diagrammatic illustration. The pectorals barely reach to the bases of the ventrals.

P. about 10. V. 8. D. $13\frac{1}{2}$. A. $17\frac{1}{2}$. About 30–32 scales in the lateral line.

Shoulder dot present. PLO close to the lateral line. 2 PVO almost vertically above each other. 5 PO, the fourth elevated to a level about mid-way between the levels of the two PVO and situated almost vertically above the third PO. VLO about midway between lateral line and ventral fin. 4 VO, elevation of second VO hardly perceptible. 3 SAO, very broadly angulate. First SAO vertically above the third VO, slightly lower than VLO. Second and third SAO forming a straight but very oblique series with the last VO. Second SAO very slightly higher than the first and about equally spaced between the first and the third SAO. Upper SAO at the lateral line and notable for its very posterior position, being always situated well behind the first AO anterior, usually not far from the vertical from the second AO anterior and sometimes even above the

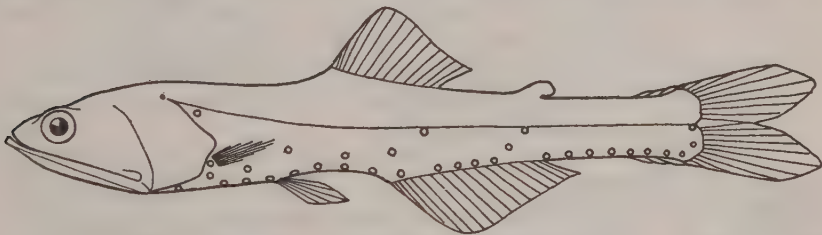


Figure 13. *Lampanyctus idostigma* n. sp.

AO		posteriores (4 Prc)		
		5	6	7
anteriores	5		10	8
	6	2	5	1

interspace between the second and third of the latter organs. 5 + 6 AO in the type, with the material as a whole showing the combinations given in the accompanying table. First SAO anterior not noticeably lower than the rest of the series, but separated from the latter by a more or less conspicuously enlarged interspace, often equaling fully two of the interspaces between the following organs. 2 Pol, the upper at the lateral line. AO posteriores entirely behind the base of anal fin, the first organ following closely upon the last anal ray. 4 Prc, confluent with the AO posteriores. Second to fourth Prc broadly angulate, with the last Prc in the end of the lateral line approximately vertically above the third Prc, which is well behind the second.

3 supracaudal and only 3 infracaudal luminous scales.

In the absence of the shoulder dot, *L. idostigma* would come under point *zz* in the previously rendered key to the genus *Lampanyctus* (Parr, 1928, p. 87) but would be differentiable from the other species falling into the same group (*L. niger*, *L. ater* and *L. cuprarius*) by the low position of its VLO, as well as by several other details in its appearance.

Genus **Diaphus** Eigenmann and Eigenmann

Diaphus pacificus n. sp.

1 specimen, No. 2690 B. O. C. May 31, 1926. N. 16° 14'. W. 99° 36' 30".
1800 fathoms depth to bottom. 625 fathoms cable out.

Total length without caudal fin 28 mm. Proportions in per cent of the length without caudal fin: Greatest depth 27. Length of head 31. Diameter of eye 8. Length of snout 7. Length of maxillary 22. Snout to dorsal fin 45. Snout to

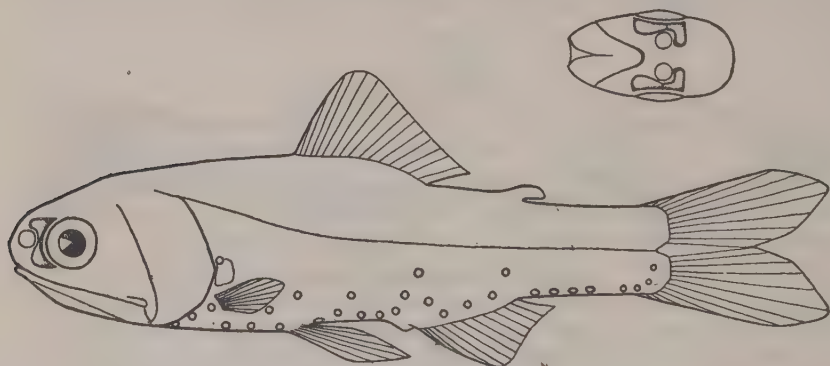


Figure 14. *Diaphus pacificus* n. sp. Frontal view of head above.

ventrals 45. Snout to anal fin 65. Base of dorsal fin 21. Base of anal fin 15. Length of caudal 28.

D. $14\frac{1}{2}$. A. $12\frac{1}{2}$. P. 9. V. 7. 32 scales in the lateral line.

Snout very blunt, slightly prominent. Eyes comparatively small, about 4 in head, far from the dorsal profile. Praemaxillary margin somewhat oblique. Pectorals small, just reaching to the ventrals, which are inserted immediately below the origin of dorsal fin. Origin of anal fin at the vertical from the end of dorsal fin. Dorsal fin-base larger than anal.

PLO nearer to pectoral fin than to the lateral line, its distance from the former only about two-thirds of its distance from the latter. 2 PVO, in a straight series with the first PO. 5 PO, the fourth elevated approximately to the level of upper PVO. VLO very low, its distance from the ventrals only about half of its distance from the lateral line. 5 VO, the third organ very sharply elevated approximately to the level of the VLO, forming a rather acute isosceles triangle

with the second and the fourth organ of the same series, the distance between the latter being hardly any larger than the distance between the fourth and fifth VO. First to third VO in a somewhat curved, not an entirely straight, series due to the elevation of the third organ. 3 SAO in a straight series. Lower SAO almost in a series with fourth and fifth VO or only slightly elevated above the level of these organs, being slightly closer to the latter of them than they are to each other. Second SAO somewhat nearer to the lower SAO than to the upper. Upper SAO about 3 of its own diameters below the lateral line. 4 + 4 AO. First AO anterior sharply elevated, nearly to the level of the second SAO. 1 Pol, more than 2 of its own diameters below the lateral line. AO posteriores entirely behind the base of anal fin. 4 Prc, in an evenly curved series, with the upper organ more than 2 diameters below the lateral line.

2 antorbital organs on each side, both fairly large and conspicuous. The upper antorbital extends mesad to or somewhat beyond the vertical from the centre of the nasal organ, while the anterior margin of the lower antorbital is curving gently forward below the nostril, as shown in figure 13. The upper antorbitals of the two sides remain separate from each other by about their own width or slightly more, the lower antorbitals by about twice that distance at the least.

A large, luminous scale at PLO.

In the previously rendered key to the genus *Diaphus* (Parr 1928, pp. 114-123) *D. pacificus* would come under point X, B, 1 (loc. cit., p. 121), but would be easily distinguished from the only other species falling under the same division, *D. coeruleus* Klunzinger, by the lower number of AO, by not having the last AO anterior elevated, by the arrangement of the VO, and by other features of less importance.

Family SCOPELARCHIDAE

Genus *Scopelarchoides* Parr

Scopelarchoides nicholsi Parr

Scopelarchoides nicholsi Parr 1929, p. 16.

1 specimen, No. 2646 B. O. C. May 28, 1926. N. 24° 07'. W. 108° 40'. 286 fathoms.

2 specimens, No. 2300 B. O. C. (Type and Cotype). May 31, 1926. N. 16° 14'. W. 99° 36' 30". 1800 fathoms depth to bottom. 625 fathoms cable out.

1 specimen, No. 2644 B. O. C. June 3, 1926. N. 11° 05'. W. 89° 20' 45". 2000 fathoms depth to bottom. 300 fathoms cable out.

1 specimen, No. 2645 B. O. C. Pacific 1926. No date.

This species, and the genus it represents, is easily distinguished from its nearest ally, *Scopelarchus*, by the characteristic incompleteness of its abdominal musculature, in which large intermuscular foraminae are developed in the man-

ner already previously described (Parr, 1929, p. 14), by the very great development of its ventral fins, which are longer and larger than the pectorals, by the very long caudal fin and by other features of minor importance. It is also well differentiated from the genus *Scopelarchus* by significant differences in its anatomy. The accompanying illustration and table of measurements may serve to supplement the original description.



Figure 15. *Scopelarchoides nicholsi*.

MEASUREMENTS OF *Scopelarchoides nicholsi* Parr

Total length without caudal fin in mm.		110 ¹	113 ²	115	43.5
Greatest depth of body		18	17	18	17
Length of head		25	25	24	26
Diameter of eye		7.3	5.9	6.0	4.5
Length of snout		6.8	6.0	6.5	8.5
Lower jaw	In	17	18	16	17
Maxillary	per cent	14		14	16
Snout to D.	of	37	39	37	39
Snout to V.	the	41	42	40	39
Snout to A.	total	60	63	60	55
Base of D.	length	4		4	5
Base of A.	without	26	26	27	31
Length of P.	caudal	17	16	17	16
Length of V.	fin	24	23	21	18
Length of C., upper lobe		23	24	23	24
Length of C., lower lobe		31	30	28	30
Depth of caudal peduncle		7	8	8	7
Length of caudal peduncle (measured from end of A.)		14		14	14

¹ Type

² Cotype

Praemaxillary with numerous, small, subequal, decurved and depressible teeth in the anterior half and about 40-45 minute, erect and fixed teeth in the

posterior half, all in a single series. Palatines each with 2 compressed, broadened and enlarged fangs anteriorly, followed by a double series of long, slender teeth, all depressible. Lower jaw with about one dozen compressed and depressible teeth on each side. Dentition on tongue as in *Scopelarchus* (see Parr, 1929, p. 14, fig. 4).

Scales cycloid, very thin and small, except in the lateral line, where they are greatly enlarged.

D. 6-7. A. 21-23. P. 20-22. V. 9.

The eyes are less telescopically formed than in *Scopelarchus anale*, retaining to some extent, the regular shape of the eyeball itself, while the lens has become dorsal and strongly excentric in the adults and the orbits only narrowly separated from each other. In the youngest specimen (43.5 mm., exclusive of the caudal) this excentricity has apparently just begun to develop and the interorbital separation is relatively wider.

APODA

Suborder *ANGUILLIFORMES*

Family *CONGRIDAE*

Genus *Uroconger* Kaup

Uroconger varidens Garman

Uroconger varidens Garman 1899, p. 304, pl. LXI, fig. 1.

1 specimen, No. 2706 B. O. C. May 28, 1926. 24° 07' N. 108° 40' W. 286 fathoms.

By gradual and uncoördinated accumulation of scattered records, descriptions and incomplete revisions the taxonomic status of the species included in the genus *Uroconger* and related (or identical?) genera (e. g., *Ariosoma*, *Xenomystax*, etc.) has reached to such a state of obscurity and confusion as to practically defy an unequivocal identification of any single form on the basis of the existing literature. Through actual comparison with the type sample of *Uroconger varidens*, in the Museum of Comparative Zoology of Harvard University, the author has, however, been able to convince himself of the probable identity of the single specimen now at hand with the species described by Garman. The available material, and the author's opportunities, do, on the other hand, not allow of any further discussion of the possible relationship or identities with further descriptions of similar forms, under different classifications and specific designations.

A few measurements may be of value for further comparisons with other collections.

Further concordance is found by a comparison of the fin counts of the specimen now at hand with those recorded by Garman, the latter being given in parenthesis in the following list: D. 222(209). A. 158(152). P. 19(19).

MEASUREMENTS OF *Uroconger varidens* Garman

Specimens		Types		2706 B.O.C.
Length without caudal fin in mm.		315	156	130
Length of head	In	21	24	21
Diameter of eye	per cent	2.8	3.2	2.6
Length of snout	of the	4.8	4.6	4.6
Cleft of mouth	length	6.5	7.2	6.3
Lower jaw	without	8.0	9.5	7.8
Length of pectorals	caudal	7.3	7.4	7.7
Snout to D.	fin	21	22	21
Snout to A.		41	42	42

The perfect agreement between the larger of the types and the specimen of the Bingham Oceanographic Collection is particularly striking (see the table above), while the smaller type specimen differs somewhat in having a quite noticeably larger head than the other two examples compared. More material is necessary to decide whether this deviation should be of any taxonomic significance.

Suborder *NEMICHTHYDIFORMES*Family *NEMICHTHYDIDAE*Genus *Nemichthys* Richardson*Nemichthys scolopaceus* Richardson

- 1 specimen, No. 2669 B. O. C. April 17, 1926. $22^{\circ} 50' 20''$ N. $109^{\circ} 48' 15''$ W. Depth to bottom 525 fathoms (600 fathoms cable out? See page 3).
 5 specimens No. 2659 B. O. C. May 28, 1926. N. $24^{\circ} 07'$. W. $108^{\circ} 40'$. 286 fathoms.
 1 specimen No. 2660 B. O. C. June 3, 1926. N. $11^{\circ} 05'$. W. $89^{\circ} 20' 45''$. 300 fathoms cable out.

Here provisionally identified on the basis of the interpretation of the species *N. scolopaceus* rendered by Roule and Bertin (1929), the material being inadequate to provide a test for their contention that all nominal forms of *Nemichthys* previously described should properly be referred to one single species.

BERYCIFORMES

Family *MELAMPHAIDAE*Genus *Melamphaes* Günther

Through the world revision of the genus *Melamphaes* recently published by J. R. Norman (1929c) the task of identifying and differentiating the species included in the collections here reported upon has been rendered comparatively

simple for the present writer. Since the large-scaled group of the genus has been found to include three, instead of only two, species, *M. bispinosus* Gilbert being re-established as distinct from *M. mizolepis* Günther, and since furthermore a new species *M. macrocephalus* has also been found among the small-scaled forms, it has nevertheless been deemed desirable to republish a modified key to the entire genus. On all points, except where the differentiation of the above mentioned species is concerned, however, the following key will be found to be a straight quotation from the one rendered by Norman (op. cit., pp. 155-56), to whom the credit belongs for first coördinating the multitudinous and scattered descriptions which have gradually accumulated in the literature. In adopting this key, however, the author would like to remark that the rostral spine of the new species is so feeble that even a very slight mutilation would probably suffice to remove it completely, and its presence or absence can therefore in this case hardly be considered very significant for the identification. It therefore seems advisable to enter and differentiate this and similar species under both headings with regard to this feature.

Key to the genus *Melamphaes*, according to Norman (1929), with additions.

I. More than 20 scales in a longitudinal series.

A. No spine on the snout between the nostrils; (origin of anal below last two or three rays of dorsal or further back¹).

1. Dorsal with 17 to 20 (II or III 14-17) rays.

a. Teeth in bands in both jaws; 8 or 9 gillrakers on lower part of anterior arch; origin of anal well behind last ray of dorsal. [Head $3\frac{1}{2}$ in the length].² 1. *typhlops*.

b. Teeth in two or three irregular series in both jaws; 15 to 17 gillrakers on lower part of anterior arch; origin of anal below or immediately behind last ray of dorsal.

X. Head $2\frac{5}{8}$ to $3\frac{1}{2}$ in the length; origin of pelvic below or a little behind pectoral base. [Eye 5 to $6\frac{3}{4}$ in head].² 2. *microps*.

xx. Head $2\frac{1}{2}$ in the length; origin of pelvic a little in front of pectoral base. [Eye 6 to $6\frac{1}{2}$ in head, $1\frac{1}{2}$ in snout].² 3. *lugubris*.

xxx. Head only 2 to $2\frac{1}{4}$ in the length. Origin of pelvic a little in front of pectoral base. Eye $8\frac{2}{3}$ to $9\frac{2}{3}$ in head, 2 to $2\frac{1}{2}$ in snout. 4. *macrocephalus*, n. sp.²

2. Dorsal with 12 to 14 (II-III 9-12) rays.

a. Dorsal III 9; diameter of eye $4\frac{1}{4}$ to $5\frac{1}{2}$ in head; maxillary extending to below middle of eye or a little beyond.

5. *nordenskjoldii*.

¹ Of uncertain value; See page 43.

² Entered by the author.

- b. Dorsal II-III 11-12; diameter of eye 8 to 11 in head; maxillary extending beyond posterior margin of eye.
 - x. Origin of pelvic distinctly behind pectoral base; snout nearly 4, diameter of eye 8 to 9 in head.
 - 6. *robustus*.
 - xx. Origin of pelvic below or immediately behind pectoral base; snout $3\frac{3}{4}$, diameter of eye about 11 in head.
 - 7. *nigrescens*.
- B. A spine on the middle of the snout between the nostrils or anterior parts of the eyes;¹ (origin of anal below posterior half of dorsal).²
 - 1. Origin of pelvic a little in front of pectoral base; caudal peduncle 4 to $4\frac{1}{2}$ times as long as deep; diameter of eye $3\frac{1}{2}$ to $3\frac{3}{4}$ in head.
 - 8. *megalops*.
 - 2. Origin of pelvic slightly in front of pectoral base; caudal peduncle 2 to $2\frac{1}{2}$ times as long as deep; diameter of eye $8\frac{1}{2}$ to $9\frac{1}{2}$ in head; head 2 to $2\frac{1}{8}$ in length; interorbital width 4 to $4\frac{1}{2}$ in head.
 - 4. *macrocephalus*, n. sp.³
 - 3. Origin of pelvic below or a little behind pectoral base; caudal peduncle $2\frac{1}{4}$ to 3 times as long as deep.
 - a. Diameter of eye 7 to $8\frac{1}{2}$ in head, maxillary extending to a little beyond posterior margin of eye.
 - x. Dorsal III 12-13; origin nearer end of snout than base of caudal; interorbital width $3\frac{1}{4}$ to $3\frac{1}{2}$ in head.
 - o. Head $2\frac{3}{8}$ to $2\frac{2}{8}$ in the length; last ray of dorsal behind level of middle of anal; caudal peduncle $2\frac{1}{2}$ to $2\frac{2}{3}$ times as long as deep.
 - 9. *cristiceps*.
 - oo. Head nearly 3 in the length; last ray of dorsal a little in front of level of middle of anal; caudal peduncle nearly 3 times as long as deep.
 - 10. *crassiceps*.
 - xx. Dorsal III 10 (or 11); origin a little nearer base of caudal than end of snout; interorbital width $4\frac{2}{8}$ in head.
 - 11. *unicornis*.
 - b. Diameter of eye 5 to $6\frac{1}{8}$ in head; maxillary extending to below middle or posterior part of eye.
 - x. Head nearly 3 in the length; origin of dorsal nearer end of snout than base of caudal; caudal peduncle nearly 3 times as long as deep.
 - 12. *atlanticus*.
 - xx. Head $2\frac{1}{4}$ to $2\frac{1}{2}$ in the length; origin of dorsal nearer base of caudal than end of snout; caudal peduncle $2\frac{1}{2}$ times as long as deep.
 - 13. *nigrofulvus*.

¹ Sometimes broken off in much mutilated examples.

² Of uncertain value. See page 43.

³ Entered by the author.

II. Less than 20 scales in a longitudinal series.

A. Head only 2 to $2\frac{1}{4}$ in length. Diameter of eye 8 to 9 in head, length of snout about $3\frac{1}{2}$ to $4\frac{1}{2}$. 14. *bispinosus*.¹

B. Head about $2\frac{1}{2}$ to a little more than 3 in length. Diameter of eye less than 8 in head.

1. Anterior profile strongly arched; height of head (at level of preopercular ridge) $1\frac{1}{8}$ to $1\frac{1}{4}$ in its length; diameter of eye $4\frac{1}{2}$ to $5\frac{1}{2}$ in head, length of snout $4\frac{3}{8}$ to 5. 15. *beanii*.

2. Anterior profile scarcely arched; height of head (at level of preopercular ridge) $1\frac{1}{2}$ to $1\frac{3}{4}$ in its length; diameter of eye 6 to $7\frac{3}{4}$ in head, length of snout $4\frac{1}{8}$ to $4\frac{1}{2}$. 16. *mizolepis*.

***Melamphaes macrocephalus*, n. sp.**

19 specimens Nos. 2697 (TYPE) and 2698 B. O. C. May 31, 1926. $16^{\circ} 14' N$. $99^{\circ} 36' 30'' W$. 1800 fathoms depth to bottom. 625 fathoms cable out.

5 specimens No. 2699 B. O. C. June 1, 1926. $14^{\circ} 30' 30'' N$. $96^{\circ} 14' W$. 2100 fathoms depth to bottom. 625 fathoms cable out.

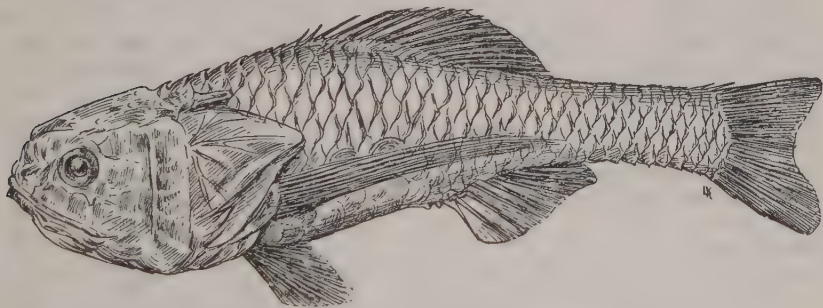


Figure 16. *Melamphaes macrocephalus* n. sp.

As already above stated, the weakness of the rostral spine in the form here dealt with makes it advisable to compare it both with those species in which such a spine is known to be found and with those in which it has not, as yet, been recorded. Although in most other respects very similar to *M. lugubris* Gilbert the specimens now at hand differ sufficiently from Gilbert's species with regard to the dimensions of their heads and eyes to make their identity with the latter form seem rather improbable. It should be kept in mind, however, that the type and only known specimen of *M. lugubris* is nearly twice as large (about 90 mm.) as the largest of those included in the present samples (54 mm.); but, while this difference might possibly to a certain extent explain the larger heads in the latter, it would be contrary to general experience on the late ontogenetic changes in proportions to try to also make this difference in size account for the smaller

¹ Entered by the author.

eyes in the smaller specimens, the usual trend of development rather tending to point in exactly the opposite direction, particularly in very small eyed species, such as the ones here considered (very large eyed species will sometimes form exceptions to this rule). It is thus quite possible that the observed differences in the relative dimensions of the eyes will prove to be even more significant than they appear at present, when a complete series of specimens of comparable sizes become available for investigation. Until such time the samples here reported upon must, at least provisionally, be referred to a separate species. The differentiation of *M. macrocephalus* from the other spine-bearing forms is sufficiently indicated in the preceding key.

TABLE OF MEASUREMENTS OF *Melamphaes macrocephalus*, n. sp.

Length without caudal fin in mm.		54 ¹	51	36.5
Greatest depth		31	30	30
Length of head		47	44	45
Diameter of eye		5	5	5.5
Length of snout	In	11	10	11
Interorbital width	per cent	16	16	17
Length of maxillary	of	20	20	20
Length of P.	length	36	36	33
Length of V.	without	25	24	25
Length of free caudal peduncle	caudal	22	23	22
Least depth of caudal peduncle	fin	10	9	9.5
Snout to D.		47	47	49
Snout to A.		71	67	67
Base of D.		28	29	29
Base of A.		12	11	13

¹ Type.

D. $17\frac{1}{2}$ (III + $14\frac{1}{2}$). A. $9\frac{1}{2}$ (I + $8\frac{1}{2}$). P. 14. V. I + 7. Scales in longitudinal series 25-26. Gillrakers in lower part of anterior arch 15.

Head very large, 2 to $2\frac{1}{3}$ in length without caudal. Eyes very small, 8.4 to 9.4 in head and 2 to 2.2 in the length of the snout, which is contained about 4 to $4\frac{1}{2}$ times in the length of the head. Interorbital width $2\frac{2}{3}$ to 3 in head. Head rough and cavernous, but with moderate crests and ridges for the genus. A minute and feeble spine on the middle of the snout between the nostrils, not perforating the skin when the specimen is intact. 2 inconspicuous spines at the angle of the preoperculum. Preopercular margin vertical. Mouth very oblique. The symphyseal point of the lower jaw reaching approximately to the level of the lower margins of the orbits. The maxillary extends somewhat beyond the vertical from the posterior margin of the eye. Teeth small, in two or three series

in each jaw, with an inner, narrow band of minute villiform teeth in the posterior half or two-thirds of the upper jaw.

There is a very considerable amount of variation in the position of the anal fin relative to the dorsal, the latter usually terminating above the anterior third of the anal fin but in some cases extending to above the middle of the anal and in others scarcely reaching beyond the anal origin. The variations in this regard seem to be determined in a considerable measure by the state of contraction and flexure of the specimen, and the feature can therefore hardly be used for taxonomic differentiation of the various species as suggested in Norman's key.

The ventral fins are inserted immediately in advance of the pectoral fin bases, and the dorsal has its origin slightly nearer to the snout than to the base of caudal fin.

The caudal peduncle is relatively short, but slender.

Color deep brown, paired fins pale, dorsal very light dusky, anal light dusky, caudal dusky.

***Melamphaes bispinosus* Gilbert 1915**

Melamphaes bispinosus Gilbert 1915, p. 325.

?*Melamphaes mizolepis* (partim) Norman 1929c, p. 168.

10 specimens, No. 2700 B. O. C. May 28, 1926. 24° 07' N. 108° 40' W.
286 fathoms.

3 specimens, No. 2701 B. O. C. May 29, 1926. 20° 48' 15" N. 106° 11' 50".
W. 540 fathoms cable out.

58 specimens, No. 2702 B. O. C. May 31, 1926. 16° 14' N. 99° 36' 30" W.
1800 fathoms depth to bottom. 625 fathoms cable out.

18 specimens, No. 2703 B. O. C. June 1, 1926. 14° 30' 30" N. 96° 14' W.
2100 fathoms depth to bottom. 625 fathoms cable out.

2 specimens, No. 2704 B. O. C. June 3, 1926. 11° 05' N. 89° 20' 45" W.
2000 fathoms depth to bottom. 300 fathoms cable out.

53 specimens, No. 2705 B. O. C. Pacific 1926. No data.

Various features in the proportions of the specimens now at hand led the author to suspect that they could not be identified with *M. mizolepis* Günther,

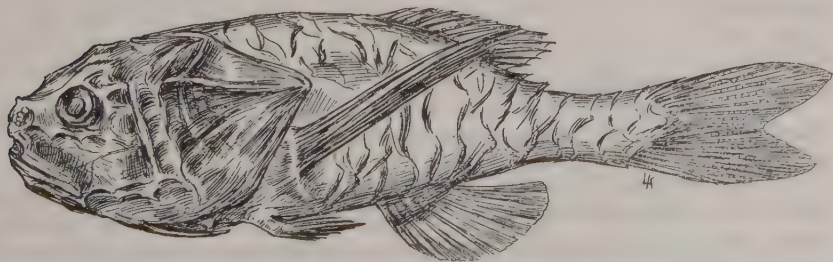


Figure 17. *Melamphaes bispinosus*.

as defined by Norman (1929c, p. 168), although their general appearance would seem to be in very good accordance with the description of the latter species. This suspicion has been confirmed by Mr. J. R. Norman, who has kindly compared a sample from the collections here reported upon with his own material, and to whom the author is further indebted for an Atlantic specimen of *M. mizolepis* obtained in exchange from the British Museum (Natural History). Comparison with the type of *M. bispinosus* Gilbert in the United States National Museum has, on the other hand, failed to show any significant difference between this species, which was tentatively included by Norman in the synonymy of *M. mizolepis*, and the deviating form now at hand. *M. bispinosus* can consequently be re-established as a distinct species.

The following table of measurements will suffice to indicate the proportions of the species compared.

MEASUREMENTS OF *Melamphaes bispinosus* Gilbert and *M. mizolepis* Günther

Species		<i>bispinosus</i>						<i>mizolepis</i> ¹
Length without caudal fin in mm.		[73] ²	62	54	52	50	41	48
Length of head	In per cent of length without caudal fin	43[45]	46	46	45	45	49	38
Greatest depth of body		30	28	29	28	27	27	23
Diameter of eye		5	5.5	5.5	5.5	5.0	5.5	4.2
Length of snout		12.5	11	11	11	12	11	10.5
Interorbital width		16.5	15	15	15	15	16	10
Length of maxillary		16.0	15	16	15	15	17	14.5
Length of free caudal peduncle		26	27	29	29	30	28	31
Least depth of caudal peduncle		12[10.5]	9	9	9	8	8.5	9.5
Snout to D.		47[48]	51	53	51	50	53	46
Snout to A.		63	63	62	61	64	68	57
Base of D.		23.5[22]	23	20	21	19	21	21
Base of A.		10	10.5	9	10.5	10	10	11.5
Length of P.		29	32	30	33	29	32	25
Length of V.		—	11	14	13	12	14	11.5

¹ Atlantic specimen from British Museum.

² Type measurements according to Gilbert, checked by the writer. Deviating figures obtained by the author are given between brackets.

The relative depth of the caudal peduncle is conspicuously greater in the type than in the specimens now at hand, although the difference is smaller according to the measurements obtained by the present writer than according to those of Gilbert's description (see the table). This, however, seems to be the only differ-

ence of any significant magnitude at all, and may in itself be partly due to the difference in size between the specimens compared. There is thus no adequate reason for doubting the identity of the samples now at hand with Gilbert's species.

The writer had been able to confirm Norman's suspicion that *M. bispinosus* belongs to the large-scaled group of the genus *Melamphaes* and not to the small-scaled forms as assumed by Gilbert. Although the skin is very badly damaged it still has the unmistakable appearance of the large-scaled members of the genus.¹ The material now at hand shows 9-13 scales in a longitudinal series.

In all other respects as described by Gilbert.

CHIASMODONTIFORMES

Family CHIASMODONTIDAE

In his revision of this family, Norman (1929b) recognizes four separate genera of the Chiasmodontidae, viz.: *Chiasmodon*, *Dysalotus*, *Pseudoscopelus* and *Odon-tonema*. According to this classification, the new species included in the collections here reported upon should be referable to the genus *Dysalotus*. Comparison with a specimen representative of the type species, *Dysalotus alcocki* McGilchrist, obtained in the Atlantic during the third oceanographic expedition of the Pawnee, has, however, convinced the author that a further taxonomic subdivision may be justified at this point. A new genus, *Dolichodon*, is therefore introduced.

This new genus differs from the genus *Dysalotus*, as herewith restricted, in only having two rows of teeth in each jaw, with the inner series sharply differentiated from the outer by an abrupt and very great increase in the size of its teeth and by their strong curvature.

In *Dysalotus* the teeth are all perfectly straight, arranged in four series in each jaw and only gradually increase in size from the outer row to the inner where they are longest, without, however, attaining even nearly to the relative length of the inner row of curved fangs in *Dolichodon*.

As far as the available material (including also a new species of *Dolichodon* from the Atlantic) goes, the genus *Dolichodon* also seems characterized by a relatively slighter development of the dentition on palatines and gill-arches, by a smaller head with a more deeply cavernous dorsal surface and by somewhat larger pectoral fins than found in *Dysalotus* (*alcocki*).

As here interpreted, the genus *Dysalotus* only includes one single species, *D. alcocki* McGilchrist, *D. macrodon* Norman being referable to our new genus.

Genus *Dolichodon* n. gen.

DIAGNOSIS: Teeth in only two series in each jaw. Inner series in both jaws greatly enlarged and strongly curved, outer series smaller, straight or slightly

¹ This conclusion is concurred in by Mr. G. D. Myers, of Stanford University, who has also examined the type of Gilbert's species.

curved. Teeth present on palatines and gill-arches, but sometimes in a reduced or rudimentary state in both situations. Palatine teeth in a single series. Dorsal surface of the head with large mucuous cavities. Only a slight emargination between the praemaxillaries. Pseudobranchiae very small. Four gills, with a small slit behind the fourth arch.

GENOTYPE: *Dolichodon normani* n. sp.

GENERAL CHARACTERS: Head rather small, its length contained about four times or more in the total length without caudal fin. Pectorals long, about two-thirds, or more of the length of head. Dentition on palatines and gill-arches always less developed than in *Dysalotus*.

In the features of the dentition this genus shows great similarity with Weber's definition and description of the genus *Odontonema* (Weber, 1913, p. 148), and in the greatly reduced state of the teeth on palatines and gill-arches in *Dolichodon normani*, a further approximation to Weber's genus is observed. *Dolichodon* can thus be regarded as intermediate between *Dysalotus* and *Odontonema*. The latter genus should be differentiated from the others of this series by the presence of only 3 gills without any slit behind the third, instead of four with a slit behind the fourth as in *Dysalotus* and *Dolichodon*. This distinction is certainly ample enough to justify the maintenance of a separate genus, while the inadvisability of basing the differentiation on the presence or absence of palatine dentition and pseudobranchiae is clearly shown by the rudimentary state of these parts in *Dolichodon normani*.

Key to the species:

- I. Eye moderate, about $6\frac{1}{2}$ in head. Second dorsal fin with about 28, pectorals with only 11 rays. Jaws moderately arched, with about 7-10 fangs in the inner enlarged series.¹
- II. Eye very small, about 9 in. head. Second dorsal fin with only about 22, pectorals with 13 rays. Both jaws strongly arched with the concavities of their arches turned towards each other, so that their middle parts remain separate from each other by a space about half as wide as the length of the snout, when end of the latter is touched by the anterior end of the lower jaw. Only about four greatly enlarged fangs in the inner series of each jaw.

D. macrodon Norman

D. normani n. sp.

Dolichodon normani n. sp.

1 specimen, No. 2693 B. O. C. May 31, 1926. N. $16^{\circ} 14'$. W. $99^{\circ} 36' 30''$. 1800 fathoms depth to bottom. 625 fathoms cable out.

Total length without caudal fin 105 mm. Proportions in per cent of total length without caudal fin: Greatest depth 13. Length of head 25.3. Diameter

¹ According to the figure (Norman, 1929 b, fig. 10, p. 542).

of eye 2.8. Snout 8.4. Maxillary 17. Lower jaw 19. Interorbital width 5.9. Longest fang (in praemaxillary) 3.3. Space between middle parts of upper and lower jaws with the mouth closed 4.6. Snout to dorsal fin 28.6. Snout to anal fin 53.5. Length of free caudal peduncle 9.0. Least depth of caudal peduncle 3.5. Length of pectoral fin 22.

The specimen has unfortunately lost its skin completely and also the distal parts of all the fin-rays (and spines) except those of the pectoral fins. Lateral line pores and dermal armature can therefore not be made out.

D¹. XII. D². I + 23½. A. I + 24½. P. 13. V. I + 5.

Branchiostegals 6. Approximately 38 segments.

The appearance of the head is most conspicuously characterized by the strong curvature of the jaws, which has already been sufficiently dealt with in the preceding key and record of measurements. Eye situated approximately opposite the middle of the maxillary. Praemaxillaries with about 20 depressible straight teeth in the anterior two-thirds (approximately) of their outer row,

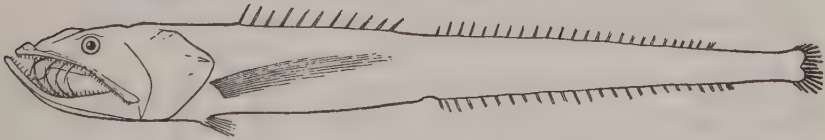


Figure 18. *Dolichodon normani* n. gen. et sp. Accurate numbers of fin rays in the text.

which extends from end to end of the jaw and is continued posteriorly by about 15 more densely arranged non-depressible teeth. The four long, decurved and depressible fangs of the inner row are inserted over about two-thirds of the distance from below the middle of the eye to the end of the snout. Lower jaw with about 23 straight, depressible teeth in the outer series and four long, decurved and depressible teeth inserted in the middle third of its length. Palatines each with a single series of very small, almost rudimentary teeth which do not penetrate through the integuments in the roof of the mouth. Minute, wide-set teeth present on the gill-arches, about 4 (3-5) in the upper half and about 10-15 in the lower half of each arch. Preopercular margin strongly oblique, almost parallel with the posterior third of the maxillary. Opercular crests terminating in feeble, free points, too weakly ossified to be properly designated as spines.

Ventrals below the anterior ends of the pectoral fin-bases. Second dorsal and anal fin origins opposite each other—anal termination slightly behind that of second dorsal.

Named in honor of Mr. J. R. Norman, of the British Museum (Natural History).

ANACANTHINI

Family **GADIDAE**Genus **Microlepidium** Garman

Microlepidium grandiceps Garman [1899, p. 181 and plates 43, figs. 1-5, and 83, fig. 1]

3 specimens, No. 2652 B. O. C. May 28, 1926. N. 24° 07'. W. 108° 40'. 286 fathoms.

2 specimens, No. 2653 B. O. C. May 29, 1926. N. 20° 48' 05". W. 106° 11' 50". 540 fathoms cable out.

As the above listed samples contain a very good series of various sizes, in an excellent state of preservation, a few measurements may be of interest, as a supplement to Garman's description, with which the material is in every respect perfectly concordant.

MEASUREMENTS OF *Microlepidium grandiceps* Garman

Length without caudal fin in mm.		95	93	77	58	47
Greatest depth		21	25	21	21	21
Length of head		26	26	27	29	29
Diameter of eye		8	8	8	7.5	8
Length of snout	In	5	5	5	6	6
Interorbital width	per cent	4.7	5	4.5	5	5
Length of maxillary	of the	11	12	12	11	13
Snout to D.	length	27	30	28	29	28
Snout to A.	without	41	42	40	44	45
Length of C.	caudal	12	12	12	12	12
Length of P.	fin	21	24	24	27	25
Length of V.		23	23	27	29	33
Length of free caudal peduncle		12	11	12	—	—
Least depth of caudal peduncle		1.7	1.6	1.5	1.7	—

D. 9 + 42. A. 39. P. 19. V. 2 (counts from largest specimen only). 110-115 scales in a horizontal series.

Family **BREGMACEROTIDAE**Genus **Bregmaceros** Thompson

Although the literature of today only contains four, or possibly five, nominal species or subspecies of *Bregmaceros* for which the pretensions to true specific distinctness have not as yet been disproved, the taxonomic condition of the genus can nevertheless be designated as rather chaotic, and a complete revision of all types and other earlier identifications would be highly desirable. As a first step towards such a revision the writer has attempted to extract the essen-

tial definition of each form from the existing descriptions and from the material of *B. atlanticus* and *B. macclellandi* now at hand in the collections from the second and third oceanographic expeditions of the "Pawnee." For the well established synonymies of the older species the reader must be referred to the literature listed under each name, the lists here given being in no sense the complete lists of synonyms and references for these species, except for those described after 1895 (after the publication of Goode and Bean's "Oceanic Ichthyology").

- I. Uniformly dark. Interorbital space conspicuously (about one-third to one-half) wider than eye. Snout equal to or slightly longer than eye. Eye moderate, $3\frac{1}{2}$ -4 in head. Produced ventral rays equalling about two-thirds of the total length without caudal fin.

B. atlanticus Goode and Bean

B. atlanticus Jordan and Evermann 1896-1900, p. 2527.

?*B. macclellandi* Norman 1930, p. 339 (partim)?

NOTE: The suggestion made by Jordan and Evermann that this species should be only doubtfully distinct from *B. macclellandi* is quite discordant with the material at hand, consisting of the Pacific specimen recorded below as *B. macclellandi*, as well as Atlantic samples of *B. atlanticus* obtained in 1927.

- II. Dusky (?) (in formalin). Interorbital space less than one-fourth wider than eye. Snout about equal to or considerably longer than eye. Eye about $3\frac{1}{2}$ -5 (?) in head. Produced ventral rays equalling only about half of the total length without caudal fin.

B. atlanticus japonicus Tanaka 1908, p. 42.

NOTE: A very doubtful form; with type and cotype showing great discrepancies in their proportions according to the measurements recorded by Tanaka.

- III. Sides silvery. Interorbital width about equal to, or less than one-fourth ($\frac{1}{8}$) longer than eye. Snout about equal to or slightly shorter than eye. Eye (large (?) or) moderate, about (3 (?) or $3\frac{1}{2}$ to) $4\frac{1}{2}$ in head. Produced ventral rays equalling about two-thirds of the total length without caudal fin.

B. macclellandi Thompson

See below

- IV. Sides silvery. Eyes large, only about 3 in head, nearly twice as long as snout. Interorbital width little more than half of the width of eye.

B. longipes Garman 1899

B. macclellandi (Thompson) Günther 1889 (p. 25 and plate III figs. A and B)

B. macclellandi Jordan and Evermann 1896-1900, p. 2526, with earlier synonymy (? excl. of *B. bathymaster* Jordan and Bollman? See below).

¹ Norman, 1930, synonymizes the two species.

B. macclellandi McCulloch 1926, p. 29, with synonymy.

?*B. macclellandi* Norman 1930, p. 339 (partim)?

1 specimen, No. 2691 B. O. C. May 31, 1926. N. 16° 14'. W. 99° 36' 30".

1800 fathoms depth to bottom. 625 fathoms cable out.

Total length without caudal fin 47 mm. Proportions in per cent of length without caudal fin: Depth of body 14.5. Length of head 18. Diameter of eye 4. Length of snout 4. Interorbital width 4.5. Length of maxillary 7.5. Snout to A. 40. Snout to D. 42. Length of nuchal ray 25. Length of P. 11. Length of V. 63.

About 71 scales in a horizontal, and about 13 in a transverse series.

D. 1 + 15 + 17 + 19. A. 18 + 10 + 25.

Considerable probability seems to exist that more than one species may have become confused under the name of *B. macclellandi*; the present writer being particularly inclined to question the justification of combining *B. bathymaster* with *B. macclellandi* as suggested by Jordan and Evermann (1896-1900, p. 2527). According to the descriptions *B. bathymaster* would seem to have a considerably larger eye (3 in head, or about 6 per cent of the length without caudal), and also a larger interorbital width and longer snout than have been recorded for any other samples referred to *B. macclellandi*.

The specimen above recorded differs very strikingly from the Atlantic samples of *B. atlanticus*, to be reported upon in a later publication.

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SCIENTIFIC RESULTS OF THE THIRD OCEANOGRAPHIC
EXPEDITION OF THE "PAWNEE"
1927.

CERATIOIDEA

BY ALBERT EIDE PARR

INTRODUCTION

On the third oceanographic expedition of the yacht PAWNEE under the direction of Harry Payne Bingham, eighteen species of Ceratioidea altogether represented by 32 specimens, were collected.

It is rather surprising to find that eleven, or in other words more than half of the species caught are still new to science. This very plainly shows the vast amount of collecting and purely descriptive treatment of forms which must still be done before sufficient facts have been accumulated to allow of any general deductions about the distribution and other biological relations of this group.

With the scattered material and descriptions, and the worldwide distribution of many species it becomes an issue of main importance in deep sea ichthyology to try to establish as soon as possible, in the different groups, the relative values, as diagnostic characters of the different features exhibited by the specimens. To this end the author has recorded a number of different measurements, also of already described species, and even when the present material is not in itself sufficient to make any final conclusions possible, merely as contributions for comparison with other collections. A few indications may however be found already by a comparison of the material now at hand with former records, and in the case of *Melanocetus murrayi* a rather good series of different sizes was found in the present collection.

It will appear from the table, p. 27, that the largest specimen of *Melanocetus murrayi* shows quite considerable differences from the rest of the series as far as all dimensions of the head and the length of the pectorals are concerned. The relative length of lower jaw, the relative interorbital and postorbital widths and the relative length

of the pectorals are considerably smaller than in any other specimen and the relative length of the illicium is also below the average.

Concerning the dimensions of the illicium Regan 1926¹ observes that in a series of nine specimens of *Dolopichthys allector* Garman its length in the smaller specimens (20–30 mm.) was only one-fourth of the length without caudal, while in the larger ones (48 mm. and Garmans of 72 mm.) it equals one-third to one-half of the same measure. A similar relation might be indicated by the present specimens of *Melanocetus murrayi* from 17 to 60 mm. length if this possibility was not disproved by the small illicium of the largest specimen on one hand and by the long illiciums of the two smallest ones on the other. It does, however, seem rather improbable that the relative growth of these entirely homologous and analogous organs should not be essentially the same in all species, either resulting in an increase or in a decrease of the relative lengths of the organs considered with age. The series so far examined in this respect are, however, not sufficient to decide what is really the normal change of the proportions in question during growth. We are therefore not yet able to determine the systematic significance of differences between the relative lengths of the illiciums in specimens of different size. As far as the genus *Melanocetus* is concerned the changes and individual variations observed in *M. murrayi* are not sufficient to efface the value of the proportions in question as diagnostic characters of the different species. The great changes in the relative length of the illicium of *Dolopichthys allector* reported by Regan, however, warn us to be very cautious when comparing specimens of different sizes in groups where the variability and the regular changes of this character have not been made out already. Still the length of the illicium undoubtedly gives valuable hints to the identity of the specimens and its use as a diagnostic character is very helpful when other characters concur in proving the existence of a separate species.

A satisfactory measurement for the length of the head, corresponding to this measurement in other fishes, cannot be found in the Ceratioidea as the distance from the snout to the gill openings, by the lack of firm skeletonous margins around the latter, is too dependent upon quite accidental contractions, the state of preservation and so on. The most reliable expression for the size of the head is

¹ Regan, C. Tate: The pediculate fishes of the suborder Ceratioidea. The Danish "Dana" Expeditions 1920–22. No. 2, Copenhagen 1926, p. 24.

probably found in the relative length of the lower jaw, which in the examined series of *Melanocetus murrayi* varies between $\frac{2}{5}$ and about $\frac{1}{2}$ of the length without caudal, without any apparent relation to the size of the specimens, except in the case of the largest one which has the relatively shortest lower jaw. The size of the head can of course be represented by the length of the lower jaw only by comparisons within narrow systematic limits, where the proportion between head and mouth is fairly uniform.

In *Melanocetus murrayi* the length of the longest dorsal ray exhibits a surprisingly constant ratio to the total length without caudal, while the relative length of the caudal fin is distinctly decreasing with age. The variations of the pectoral fin are less regular but this fin also seems to become relatively smaller in the larger specimens.

As *Melanocetus* has no barbel and no appendages on the illicium, the above discussed series cannot tell us anything about the systematic value of the structure and proportions of these parts.

A comparison between the present specimen of *Linophryne arborifer* Regan 1925 and the description of the larger type specimen reveals some very striking differences in the proportions of the barbel and of the endfilament on the bulb, the relative dimensions of both parts being in the smaller specimen (30 mm. length without caudal) only about one-third of what they are in the larger one (50 mm. length without caudal) see p. 11. It thus seems that in this instance at least the barbel and the appendage on the illicium must be very late to develop, their relative lengths therefore being of no value at all for diagnostic purposes. It must, however, be mentioned that the barbel of *Linophryne arborifer* is entirely filamentous and possibly homologous with the terminal appendages only on the barbels of other species, in which an undivided proximal stem is found. It is therefore still to be determined whether the length of this stem may not prove to be a more reliable character, the stem of the barbel perhaps being in a similar relation to the terminal filaments as the illicium itself to its appendages.

Even if the relative lengths of the parts considered thus appear to be entirely unreliable as diagnostic characters, this does not necessarily imply that the same must also be said about their structural designs, as is clearly shown by the terminal filaments on the bulbs of the two specimens of *Linophryne arborifer* above compared. The small appendage of the smaller specimen is in its trifid structure exactly

identical with the relatively much larger appendage of the greater specimen. Other examples for comparison are difficult to find as the details of these appendages have scarcely been considered at all in most descriptions. In the present material of *Chaenophryne longiceps* Regan two distinct types of terminal filaments are found, but owing to our lack of knowledge about the variability of these parts it is impossible to give a definite systematic valuation of the differences observed. It is, therefore, for a more accurate identification of the different forms, very desirable that the individual variations in the structure of the filaments and appendages on bulbs and barbels, which in many cases are highly characteristic of the species, should be more closely examined.

There can be no doubt that our present knowledge of individual variability among the Ceratioidea and most of the other groups of deep-sea fishes is very unsatisfactory as a basis for identification and separation of species with an, in many cases, world wide distribution. All problems of distribution, which means the problems of the entire relation between the organisms and their physical environment, of course hinge upon our ability for discerning and identifying the species. Even when fully realizing that taxonomy is only a tool for science, one must therefore not forget that modern science needs very accurate tools.

LIST OF NEW SPECIES

LINOPHRYNIDAE

LINOPHRYNE Collet 1886

L. brevibarbis n. sp.

L. bicornis n. sp.

L. coronata n. sp.

ONEIRODIDAE

DOLOPICHTHYS Garman 1899

D. obtusus n. sp.

D. analogus n. sp.

D. longicornis n. sp.

THAUMATICHTHYS Smith a. Radcliffe 1912

T. binghami n. sp.

MELANOCETIDAE

MELANOCETUS Günther 1864

M. tumidus n. sp.

ACERATHIDAE

RHYNCHOCERATIAS Regan 1925

R. acanthirostris n. sp.

R. latirhinus n. sp.

LAEVOCERATIAS n. gen.

L. liparis n. sp.

LIST OF STATIONS

- STATION 11. 2/3 1927, 23° 58' N. 77° 26' W. 7000 feet wire
1 *Melanocetus murrayi* Günther 1887
1 *Melanocetus tumidus* n. sp..
- STATION 16. 9/3 1927, 23° 49' N. 76° 58' W. 7000 feet wire
3 *Melanocetus murrayi* Günther 1887
- STATION 18. 10/3, 1927, 23° 42' N. 76° 43' W. 7000 feet wire.
1 *Melanocetus murrayi* Günther 1887.
- STATION 22. 12/3, 1927, 23° 37' N. 77° 15' W. 7000 feet wire.
1 *Melanocetus murrayi* Günther 1887
1 *Rhynchoceratias acanthiostrois* n. sp.
- STATION 23. 14/3, 1927, 24° 29' N. 77° 29' W. 8000 feet wire.
1 *Cryptosparas couesii* Gill 1883
- STATION 25. 17/3, 1927, 24° 51' N. 76° 37' W. 8000 feet wire.
1 *Melanocetus niger* Regan 1925
1 *Cryptosparas couesii* Gill 1883
1 *Thaumatichthys binghami* n. sp.
- STATION 33. 22/3, 1927, 24° 11' N. 75° 37' W. 8000 feet wire.
1 *Melanocetus murrayi* Günther 1887
1 *Rhynchoceratias latirhinus* n. sp.
1 *Laevoceratias liparis* n. gen. et n. sp.
- STATION 39. 29/3, 1927, 22° 43' N. 74° 23' W. 8000 feet wire.
1 *Linophryne coronata* n. sp.
2 *Melanocetus murrayi* Günther 1887
1 *Mancalias uranoscopus* Murray 1878
- STATION 46. 4/4, 1927, 21° 46' N. 72° 49' W. 10,000 feet wire.
1 *Dolopichthys longicornis* n. sp.
- STATION 48. 6/4, 1927, 21° 44' N. 72° 43' W., 7000 feet wire.
1 *Chaenophryne longiceps* Regan 1925
- STATION 52. 11/4, 1927, 21° 30' N. 71° 11' W., 8000 feet wire.
1 *Melanocetus johnsoni* Günther 1864
- STATION 56. 13/4, 1927, 21° 20' N. 71° 13' W. 6500 feet wire.
1 *Melanocetus niger* Regan 1925.
- STATION 58. 20/4, 1927, 32° 24' N. 64° 29' W., 10,000 feet wire.
1 *Linophryne brevibarbis* n. sp.
1 *Melanocetus murrayi* Günther 1887
1 *Dolopichthys analogus* n. sp.
2 *Chaenophryne longiceps* Regan 1925
- STATION 59. 21/4, 1927, 32° 19' N. 64° 32' W., 8000 feet wire.
1 *Linophryne arborifer* Regan 1925
1 *Linophryne bicornis* n. sp.
1 *Dolopichthys obtusus* n. sp.
1 *Chaenophryne longiceps* Regan 1925.

SYSTEMATIC ACCOUNT

LINOPHRYNIDAE

LINOPHRYNE Collet 1886

Praeopercular and sphenotic spines strong. Hyoid barbel well developed. Illicium suprarostreal, bulb with appendages. Head large. Dentition strong.

Key to the species.

- I. Bulb on illicium with appendages on both sides, not only at the distal end or in the median.
 - A. Bulb with two series of rather strong, partly branching filaments on each side, and with a small terminal filament. Barbel small and thin, with a proximal undivided part equaling $\frac{2}{5}$ of its total length, then giving rise to two thin branches and ending in a thin filament.

L. brevibarbis n. sp.
 - B. Bulb with only one series of filaments on each side. Barbel "with about 16 equal, slender branches arising together from the very short basal part."².....*L. polypogon* Regan 1925.
 - C. Bulb with a simple, rather thick, hornlike filament on each side.

L. bicornis n. sp.
- II. Appendages only at the distal end or in the median of the bulb on illicium.
 - A. Barbel branching directly from the base, all branches white. Dorsal, caudal, and anal fins entirely white. Only a single trifold terminal filament at the distal end of the bulb on illicium.

L. arborifer Regan 1925.
 - B. Barbel with a longer or shorter, proximal, undivided and unbranched, black³ stem. Dorsal, caudal and anal finrays covered by black³ pigment.
 1. Bulb on illicium surmounted by a broad median ridge, posteriorly carrying a short, thick pair of filaments and anteriorly produced into a thick tubercle carrying a similar, backwardly directed pair of filaments at its end. Undivided stem of barbel very long and thin, ending in a cluster of very small filaments.

L. coronata n. sp.
 2. Bulb on illicium "ends in a pair of exceedingly short and slender threads" with "small papilla-shaped bodies on one side."⁴ Barbel with a very long undivided stem, equaling $\frac{3}{4}$ of its total

² Regan 1926 loc. cit. p. 24.

³ The black pigmentation on these parts is developed in all specimens which have been figured or described in this respect, it may however possibly be absent in very young individuals.

⁴ Collet, Robert: On a new pediculate fish from the sea off Madeira. Proc. Zool. Soc. London 1886, p. 138.

- length, dividing itself at the end into two equal, short, pointed blades which carry tubercles along their anterior margin, but no filaments.....*L. lucifer* Collet 1886.
3. Bulb on illicium with a terminal filament. The undivided stem of the barbel less than half of its total length.⁵ Barbel bearing a lateral branch before it bifurcates, "each terminal branch dividing into two long filaments, each of which bears shorter ones."⁶.....*L. macrodon* Regan 1925

Linophryne brevibarbis n. sp.

1 specimen, No. 2001 B. O. C. Station 58,20/4, 1927.

32° 24' N. 64° 29' W., 10,000 feet wire.

Total length 34 mm. Length without caudal 25 mm. Length of lower jaw 11 mm. Distance from the snout to the base of the preopercular spine 12.5 mm. Stem of illicium 4.5 mm., bulb 2.5 mm, altogether 7 mm, longest lateral appendage on bulb 2.5 mm. Width between the bases of the sphenotic spines 7 mm. Stem of the barbel to the base of the first branch 4 mm., total length of the barbel 10 mm. Diameter of the eye 2 mm. Length of preopercular spine 3 mm.

The head is of medium size, the length of the lower jaw being a little more than 2/5 of the total length without caudal, the distance from the snout to the base of the preopercular spine equaling half of the same measure.

The sphenotic and preopercular spines are equal, very long and slender. The spine at the lower, posterior angle of the lower jaw is small, but very sharp and rather prominent.

The bulb on the illicium is slightly more than half the length of the stem. There are two series of appendages on each side of the bulb, see fig. 1. The anterior series starts with a minute tubercle near the base of the bulb, then follows a filament with a short anterior branch and above this the longest appendage of this series with one or two short anterior branches and one posterior branch near its base. In the posterior series there is one unbranched filament opposite the interspace between the tubercle and the first filament of the anterior series, and one larger, branched appendage opposite the interspace between the two upper filaments of the same. The upper filament of the posterior series is the largest of all the appendages on the bulb and carries two sets of small branches at a distance above each other, each set consisting of one anterior and one posterior branch, the upper set being very small. At the distal end of the bulb there is a small, simple, central, conically elongate filament. The free ends of the central filament and of the upper filaments of both series on each side all terminate at the same level.

After an undivided stem equaling 2/5 of the entire length of the barbel a

⁵ According to figure 2, plate II, Regan 1926, loc. cit.

⁶ Regan 1926, loc. cit. p. 24.



Fig. 1. *Linophryne brevitarsis* n. s. Lateral view of the fish and enlarged, detailed drawing of the left side of the illicium. In the figure of the entire fish the illicium has been twisted, showing the frontal view of the bulb. Drawn by W. S. Bronson.

branch arises from its posterior surface, and about 3/4 of a millimeter farther down a somewhat smaller anterior branch originates. See fig. 1. The distal ends of the two branches are reaching to the same level, their proximal parts are of the same nature as the corresponding parts of the main stem, which reaches about 3 mm. beyond their ends. Both branches and the terminal filament of the main stem carry a number of sessile tubercles on their anterior surface, the proximal tubercle on the terminal filament being, however, itself produced into a minute filament.

Teeth rather small, in single series in both jaws, 3 fangs and about 4 smaller ones in each half of lower jaw and about 6 teeth on each side in upper.

The rays of the dorsal, anal and pectoral fins are covered by a not very dense black pigment. Pigment-covering of caudal rays rather scanty, the stripes constricted but not quite disappearing at the base and fading away on the distal part of the fin. Stem of illicium appearing white to the eye, a very scattered pigment only visible under a lens. Black pigment on the barbel covering the proximal parts of the two branches and the stem itself to slightly beyond the origin of the second branch.

D. 3.A. 3. P. 15. C. 2 simple rays above + 4 bifid rays + 2 single rays below.

Linophryne bicornis n. sp.

1 specimen. No. 2030, B. O. C., Station 59.21/4. 1927.

32° 19' N. 64° 32' W. 8000 feet wire.

Length without caudal fin 27 mm. Length of lower jaw 11 mm. Distance from the snout to the base of the praeopercular spine 13 mm. Stem of illicium 4 mm., lateral filament on the bulb 2.5 mm. Diameter of the eye 2.5 mm. Length of the praeopercular spine 3 mm.

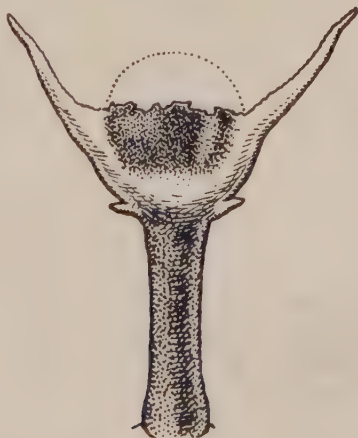


Fig. 2. Frontal view of the illicium of *Linophryne bicornis*.

The only specimen caught is in a deplorably bad condition, the barbel being torn off near the base, the distal half of the caudal fin missing, and the bulb on the illicium being torn at the end. Still what is left very distinctly separates the specimen from any formerly described species.

The head is of medium size for the genus, the length of the lower jaw being, about $2/5$, and the distance from the snout to the base of the praeopercular spine scarcely half of the total length without caudal fin.

The sphenotic spine is slightly longer than the praeopercular spine.

Apparently about or below the middle of the bulb on the illicium arises on each side one comparatively very strong tapering filament, directed outwards and upwards in a slight curve, see Fig. 2. Below this appendage a minute, conical, dermal protuberance may be seen. Other filaments on the bulb cannot be found on the present specimen. As the distal end of the organ is lacking, however, nothing can be said about the possible median appendages.

Of the barbel there is only a short basal stump left.

The teeth are of medium size, without regular arrangement in separate series. Only three fangs in each side of the lower jaw and about four smaller teeth. Upper jaws with 8 or 9 teeth on each side. A pair of small teeth on the vomer.

Pectoral, dorsal, anal and caudal rays beyond their basal parts covered with black pigment. Pigmentation interrupted by an unpigmented vertical region at the basis of the caudal fin. Stem of illicium and the stump of the barbel black.

D. 3, A. 3, P. about 15.

Linophryne arborifer Regan 1925.

1 specimen, No. 2029, B. O. C., Station 59.21/4. 1927.

32° 19' N. 64° 32' W., 8000 feet wire.

Total length 42 mm. Length without caudal 30 mm. The length of lower jaw 16 mm. Distance from the snout to the base of the praeopercular spine 18 mm. Width between the bases of the sphenotic spines 10 mm. Stem of illicium 3 mm, bulb 3 mm, terminal filament 2 mm, altogether 8 mm. Diameter of eye 3 mm. Length of praeopercular spine 4 mm, of sphenotic spine 3.5 mm. Length of the barbel 11 mm.

As far as can be made out from the very short description of the type the present specimen does not exhibit any differences whatsoever in structural designs and according to the figure⁷ both specimens agree in the complete lack of pigmentation on the rays of the vertical fins. The author has, therefore, no hesitation in identifying the two as belonging to the same species. The considerable differences found in the dimensions of the barbels and of the terminal filaments on the bulbs then become of interest as indicating a very late development or slow growth of these parts. This conclusion of course greatly influences the systematic value of the proportions of these organs, as already made out

⁷ Regan 1926 loc. cit. plate III, fig. 1.

on p. 3. In Regans specimen, with a total length without caudal of 50 mm., the barbel is "as long as fish" and the trifid terminal appendage on the bulb is longer than bulb and stem together. In the present, smaller specimen the barbel is only slightly more than one-third of the total length without caudal, and the terminal filament on the bulb is only one-third of stem and bulb together. According to the figure the spines on the head are, on the other hand, somewhat smaller in the larger specimen. In the specimen now at hand the spines are very long and slender, the praeopercular spine measuring (to its base below the skin) one-fourth of the length of the lower jaw, the sphenotic spine is a little shorter.

The enormous size of the head is probably a good character of the species, the length of the lower jaw being slightly more than half of the total length without caudal, the distance from the mouth to the base of the praeopercular spine being $3/5$ of the same measure.



Fig. 3. Left lateral view of the barbel of *Linophryne arborifer* Regan.

The terminal appendage on the bulb arises in the center of its distal end as a short peduncle carrying two short and thick lateral lobes and a central tapering filament which is several times as long as the former.

The barbel gives rise to a symmetrical pair of lateral branches directly from the base. These branches bifurcate, the inner (medial) limb being the longest. Each limb ends with a pair of small, stalked or sessile tubercles but carries no other appendages. Between and immediately below these lateral branches an anterior median branch originates carrying a great number of smaller branches of different order along its anterior surface only. The main barbel (longest branch) also carrying a profusion of smaller branches on its anterior surface only, follows close behind the just described median branch. See fig. 3. Some of the branches on the main barbel carry still smaller lateral branches, but most of the branches of higher orders both on the main barbel and on the anterior branch are median. The ultimate ends of all branches carry minute tubercles. All branches entirely white.



Fig. 4. *Linophryne coronata* n. sp. A. Lateral view. B. Illicium. C. The end of the barbel. Drawn by W. S. Bronson.

Teeth in the lower jaw in two distinct series, three long, depressible ones in the inner series on each side and about five smaller ones in the outer. Where the two series meet in front there is one long fang on each side of the symphysis. About 8 teeth in two irregular series on each side in the upper jaw.

D. 3. A. 3. C. 2 simple rays above + 4 bifid rays + 3 simple rays below (only two in Regans specimen).

Linophryne coronata n. sp.

1 specimen No. 2005, B. O. C. Station 39.29/3. 1927.

22° 42' N. 74° 23' W. 8000 feet wire.

Total length 48 mm. Length without caudal 37 mm. Length of lower jaw 13 mm. Distance from the snout to the base of the preopercular spine 16 mm. Width between the bases of the sphenotic spines 10 mm. Stem of illicium 3.5 mm., bulb 3.5 mm., terminal appendages 2.5 mm. altogether 9.5 mm. Diameter of eye 2 mm. Length of the preopercular spine 3 mm. Length of the undivided stem of the barbel 29 mm. Length from the base of the first appendage to the end of the terminal filament of the barbel 5 mm.

This species is characterized by the small dimensions of the head, the structure of the appendages on the bulb, the long undivided stem of the barbel and by the distribution of the black pigment.

The head is altogether very small compared with other species of the same genus, this being numerically expressed by the length of the lower jaw, which is only about one-third of the total length without caudal, and by the distance between the snout and the base of the preopercular spine equaling only about 4/9 of the same measure.

The bulb on the illicium is at its distal end surmounted by a thick and low median ridge, which is anteriorly produced into a short and thick tubercle carrying a pair of very short, conical, obliquely upwards and backwards directed appendages at its end. Posteriorly the ridge carries a pair of short thick filaments, one on each side, similar to the appendages on the anterior tubercle but curving outwards and upwards. Behind and below the thick ridge there is a very small and thin, pointed, triangular, median wing not reaching above the bulb itself. See fig. 4, B.

The barbel is very long and slender with only a very small cluster of filamentous appendages at the distal end. The proximal, unbranched stem equals about 4/5 of the total length without caudal, while the distance from the base of the first appendage to the end of terminal filament is only about one-sixth of the length of the stem. The appendages start with an anterior and a posterior pair of quite similar filaments. See fig. 4, C. The filaments of each pair diverge from each other in a horse-shoe fashion and carry a single series of small, stalked tubercles on the side which is turned away from the stem of the barbel. Then follow two short median, probably anterior, branches after each other, each ending in a rather big tubercle and carrying smaller, stalked tubercles on the

lower half of their anterior surface. The terminal filament is longer and more slender than the others and only carries a few very small tubercles at the base.

The teeth are not in distinct series in any of the jaws. Only three big fangs and three to four smaller teeth in each side of the lower jaw. Upper jaw with 7 to 8, all rather small teeth on each side. One pair of teeth on vomer.

The stem of the illicium and the rays of the dorsal and anal fins are covered with black pigment. Pigmentation interrupted by an entirely uncolored vertical region at the base of the caudal fin. The distal, and by far the largest part of the caudal rays however covered by black pigment. The stem of the barbel is black, but gradually fading so that it becomes entirely white where the appendages begin.

A soft dermal protuberance above the symphysis of the lower jaw.

D. 3. A. 3. P. ab. 14. C. 2 simple rays above + 4 bifid rays + 2 simple rays below.

ONEIRODIDAE

DOLOPICHTHYS Garman 1899

Sphenotic spines present, no praeopercular spines. A set of articular spines, one on the quadrate and one on the lower jaw, usually well developed. Illicium suprarostral, bulb with appendages. No barbel. No isolated ray on the back.

Key to the species.⁸

- I. Illicium $2/3$, its fully exerted basal bone more than half of the total length without caudal. Illicium with two small bulbs (according to the figure of the type-specimen).⁹ Articular spines well developed. Lower jaw about $1/3$ of length without caudal. *D. danae* Regan 1926.
- II. Illicium only about half or less of the total length without caudal fin. Only one single, simple bulb.
 - A. Bulb on illicium surmounted by many short, finger like filaments.
D. (Dermatias) platynogaster Radcliffe 1912
 - B. Bulb projecting beyond the bases of its appendages.
 1. Mandibular spine longer than that of the quadrate, both long and slender. Illicium $1/5$ to $1/4$ of total length without caudal.
D. gracilispinis Regan 1925.

⁸ *Dolopichthys niger* Brauer 1902 (Diagnosen von neuen Tiefseefischen. Zool. Anz. vol. 25. no. 668. 1902.), syn. *Oneirodes niger* Brauer 1906 (Die Tiefseefische. Wiss. Erg. "Valdivia." XV. no. 1. 1906.), seems to have only median appendages on the bulb in the form of a lobate posterior crest. Illicium about $3\frac{1}{2}$ in the total length without caudal fin.

Oneirodes cornutus Gilchrist and Bonde 1924, probably belonging to the genus *Dolopichthys* (see Regan 1926), is characterized by the complete lack of anal fin.

⁹ Regan 1926, loc. cit. plate IV, fig. 1. This peculiar character is not mentioned at all in the very short description of the species.

2. Mandibular spine not longer than that of the quadrate.

- a. "Bulb with an anterior tentacle-like and a posterior curved and compressed appendage, and with a broad anterior and a slender lateral pair of fringed flaps."¹⁰ Length of lower jaw $2/5$ to half of total length without caudal.

D. luetkeni Regan 1925.

syn. *D. heteracanthus* Regan 1925.¹¹

- b. Bulb not as above, with appendages only in or along its median.

- o. Only about 10 to 15 (20?) teeth in each half of the lower jaw.¹²

- x. Bulb "laterally compressed, provided anteriorly with a lappet or cirrus and posteriorly with a short fleshy process."¹³

D. (Monoceratias) acanthias Gilbert 1915.

- xx. Bulb "bears on its upper edge anteriorly a short digitiform limb with several short branches, behind this a tuft of very slender filaments," "and posteriorly a rather stout filament."¹⁴

D. megaceros Holt and Byrne 1912.

- xxx. Bulb with a long, thin, tentacle-like filament

¹⁰ Regan 1926, loc. cit. p. 27.

¹¹ According to Regan's descriptions and figures (Regan 1926 loc. cit.) the only differences between the two species described by him seem to be that the articular spines are "very small" and the illicium only $1/7$ of the total length without caudal in *D. luetkeni*, while in *D. heteracanthus* the spines are "well developed" and the length of the illicium $1/6$ to $1/5$ of the length without caudal. As the specimen of *D. luetkeni*, on which the description is probably mainly based, is not far from twice as long (160 mm.) as the largest specimen (90 mm.) of *D. heteracanthus*, these differences seem rather insignificant, especially as a reduction of the osseous spines is a not uncommon feature of old (large) specimens (compare for instance with the discussed specimens of *Linophryne arborifer* p. 11). In view of the fact that the, in this case, very complicated structures of the appendages on the bulb (see description above) are said to be identical in the two, the author can therefore not see any reasons for regarding them as separate species. The largest specimen may be an entirely normal old individual, the smaller specimen described as *D. luetkeni* perhaps being a slightly abnormal one, as it would not be surprising at all to find among altogether 24 specimens.

¹² *D. megaceros* having 15 to 20 teeth in upper jaw will scarcely have more than 12 to 15 in lower, even if the upper teeth are "nearly as strong as" the lower.

¹³ Gilbert: Fishes from southern California, Proc. U. S. Nat. Mus., XLVIII, 1915, p. 379.

¹⁴ Holt, E. W. L. and Byrne, L. W.: New deep-sea fishes from the southwest coast of Ireland. An. Mag. Nat. Hist. (8) I. 1908, p. 93.

arising anteriorly near its base. Posteriorly with a pair of downwards directed appendages carrying minute filaments along their posterior edge and originating close together at the median. Behind and below the pair a long and thick tubercle carrying a number of small terminal filaments.....*D. obtusus* n. sp.

oo. About 25 or more teeth in each half of the lower jaw.

x. Illicium only about $1/8$ or less of the total length without caudal.

v. Only about 35 teeth in each side of upper jaw. Bulb with a median, s wollen, crest-like appendage posteriorly, but with no other filaments. Illicium $1/9$ to $1/8$ of total length without caudal, lower jaw about $1/3$ of the same measure.

D. analogus n. sp.

vv. About 60 teeth in each side of upper jaw. Illicium less than $1/10$ of the total length without caudal.¹⁵

D. microlophus Regan 1925.

xx. Illicium about $1/4$ or more of the total length without caudal.

v. Bulb with an anterior tentacle-like appendage. Lower jaw only about $1/3$ of length without caudal.

D. allector Garman 1899.

vv. Bulb with a posterior, median, crest-like appendage but no other filaments. Lower jaw nearly half ($4/9$) of length without caudal.....*D. longicornis* n. sp.

Dolopichthys obtusus n. sp.

1 specimen No. 2028 B. O. C. Station 59. 21/4. 1927.

32° 19' N. 64° 32' W. 8000 feet wire.

Total length 19 mm. Total length without caudal 13 mm. Length of

¹⁵ According to the proportion between illicium and lower jaw in the illustration (Regan 1926, loc. cit. fig. 18) the latter should scarcely be one-third of the total length without caudal, the length of illicium being less than $1/10$ of the same measure. If, however, the dimension of the lower jaw is included in the "other characters like *D. heteracanthus*" (Regan loc. cit. p. 29) its length should be $2/5$ to $1/2$ of the length without caudal, in which case this would contribute another distinguishing difference between *D. microlophus* and *D. analogus*.



Fig. 5. *Dolopichthys obtusus* n. sp. Lateral view of the fish and enlarged, detailed drawing of the left lateral view of the illicium.
Drawn by W. S. Bronson.

maxillary 5.5 mm. Length of lower jaw 6 mm. Illicium 3.5 mm. Basal bone of illicium 4 mm. Distance between the bases of the sphenotic spines 3.75 mm. Length of caudal fin 6 mm.

This species is very close to *D. acanthias* Gilbert and *D. megaceros* Holt and Byrne, is however easily distinguished by the peculiar and characteristic structures of the appendages on the bulb, which seems to contribute the main differences between all the three species. As far as the present specimen is concerned it is also remarkable for the largeness of the head and the great length of its caudal fin, these characters may, however, especially in the case of the caudal fin (see p. 3), have some relation to the very small size (the youth) of the specimen and can therefore not be considered as being of diagnostic value until larger specimens have been caught and examined.

In the type-specimen the length of the lower jaw equals nearly half (between 4/9 and 1/2) of the total length without caudal, and the length of the maxillary about 2/5 of the same measure.¹⁶

The length of the caudal fin is very nearly 1/3 of the total length of the fish.

The length of the illicium equals slightly more than 1/4 of the length without caudal. One long, thin filament arises anteriorly near the base of the bulb. Posteriorly a pair of appendages originate close together by the median on the upper half of the bulb. The appendages are directed obliquely downwards and backwards and carry a single series of very short filaments in a comb-like arrangement on their posterior edge. Below this pair a median, long and very thick, evidently quite rigid tubercle protrudes backwards from the middle of the bulb at about right angles with the axis of the illicium. This tubercle carries a finger-like arrangement of very small filaments at its end. There is no external black pigmentation on the bulb except at the point of the small, central elevation at its distal end. Bulb and stem of illicium of about the same lengths.

There are only about 14 to 15 teeth in each half of the lower jaw, some more but much smaller ones in the upper. Two teeth beside each other on each side of the vomer.

The sphenotic as well as the articular spines are short, that of the quadrate slightly longer than the mandibular one.

D. 6 A. 4 P about 16. C. 2 simple rays above + 4 bifid rays + 2 simple rays below.

Dolopichthys longicornis n. sp.

1 specimen No. 2008, B. O. C. Station 46. 4/4. 1927.

21° 46' N. 72° 49' W. 10,000 feet wire.

Total length 27 mm. Total length without caudal 20 mm. Length of lower

¹⁶ In *D. megaceros* the length of the lower jaw is given as about 1/3 of the total length without caudal and the same proportion is recorded for the maxillary in *D. acanthias*.



Fig. 6. *Dolopichthys longicornis* n. sp. Drawn by W. S. Bronson.

jaw 8.5 mm. Illicium 6 mm., thereof bulb 1.5 mm. Basal bone of illicium 5 mm. Width between bases of sphenotic spines 5 mm. Snout to sphenotic spine 8 mm. Length of sphenotic spine 2 mm. Quadrate spine 1.5 mm.

This and the following species (*D. analogus*) are forming a separate group (possibly including also some others as for instance *D. microlophus* Regan 1925 the descriptions of which are incomplete) characterized by the features of the bulb on the illicium, which has only one single appendage, a median, posterior crest-like organ with a more or less drawn out and pointed upper angle. *D. longicornis* is, however, well distinguished from the other species of the group by the proportions of the illicium and of the head and by the development of its spines.

The head is rather long but not broad. The length of the lower jaw slightly more than $2/5$ of the total length without caudal.

The length of the caudal fin is only about $1/4$ of the total length of the fish.

The bulb only occupies one-fourth of the length of the illicium which equals about $2/7$ of the total length without caudal. The upper angle of the posterior median crest on the bulb is more produced and pointed than in *D. analogus*. The bulb bears no other appendages but has a slightly elevated median ridge running from its distal end towards its anterior outline, gradually disappearing before reaching the latter. There is no external pigmentation at all on the distal part of the bulb.

There are about 40 teeth, on each side in the lower jaw, some more in the upper, all rather small, those of the upper jaw being the smallest ones. 3 small teeth close behind¹⁷ each other on each side of the vomer.

The sphenotic and quadrate spines are very long and slender (see the measurements above), the latter is very prominent, protruding at about right angles to the axis of the body. The mandibular spine is, on the other hand, nearly vestigial, entirely hidden below the skin.

D. 4. A. 4. P. about 16, C. 2 simple rays above + 4 bifid rays + 2 simple rays below.

Dolopichthys analogus n. sp.

1 specimen No. 2010 B. O. C. Station 58, 20/4, 1927.

32° 24' N. 64° 29' W. 10,000 feet wire.

Total length 22 mm. Length without caudal fin 17 mm. Length of lower jaw 5.5 mm. Illicium 2 mm. Width between the bases of the sphenotic spines 4 mm.

The most characteristic features of this species are contributed by the shape and the pigmentation of the distal part of the bulb, by the size of the illicium,

¹⁷ Whether the difference between the transverse (*D. obtusus* and *analogus*) and the longitudinal (*D. longicornis*) arrangement of the teeth on the vomer is of any diagnostic value or not cannot be definitely decided until more material shows the stability or variability of these characters.

by the numbers of teeth and by the slight development of the spines on the head. The species is apparently closest to *D. microlophus* Regan, from which it is, however, well distinguished by the smaller number of teeth and by the larger illicium. The latter difference becomes doubly significant if the increase of the relative length of the illicium during growth, recorded by Regan from *Dolopichthys allector* Garman is a general, developmental feature of the genus, as the type specimen of *D. analogous* is considerably smaller than that of *D. microlophus* Regan (total length 34 mm.) It also seems probable that a more complete description of the latter would reveal further distinguishing differences between the two species.

The head is rather small, the length of the lower jaw being not quite one-third of the total length without caudal.



Fig. 7. Dorsal (A) and left lateral (B) view of the bulb of *Dolopichthys analogous* n. sp.

The length of the caudal fin is somewhat less than $\frac{1}{4}$ of the total length of the fish.

The bulb occupies more than half of the entire length of illicium which is only $\frac{1}{9}$ to $\frac{1}{8}$ of the total length without caudal. The posterior, median crest is swollen, shorter and blunter than in *D. longicornis*. The upper, anterior outline of the bulb is not gradually curved but forming a rounded angle (see fig. 7). The clavate, tubercle-like elevation at the distal end of the bulb is very distinct with black tip and a black anterior median line. There is a broadly club-shaped region of external black pigmentation on the upper anterior surface of the bulb, beginning at the base of the distal tubercle and broadening towards the anterior rounded angle at which it ends.

There are about 25 teeth in each half of the lower jaw, about 35 on each side in the upper. Two strong teeth beside each other and well apart on each side of the vomer.

Beth sphenotic and articular spines are very small, scarcely perceptible at all through the skin. Articular spines nearly equal.

D. 7 (one vestigial) A. 5, P. about 18. C. 1 simple ray above + 4 bifid rays + 3 simple rays below.

CHAENOPHRYNE Regan 1925

No sphenotic or praeopercular spines. Illicium suprarostril. No isolated ray on back. No barbel. Teeth fewer in upper than in lower jaw.

Only one species.

Chaenophryne longiceps Regan 1925.

1 specimen No. 2006 B. O. C. Station 48, 6/4, 1927.

21° 44' N. 72° 43' W., 7000 feet wire.

var. quadrifilis n. var.

1 specimen No. 2007, B. O. C. Station 58. 20/4. 1927.

32° 24' N. 64° 29' W., 10,000 feet wire.

1 specimen No. 2027 B. O. C. Station 59. 21/4. 1927.

32° 19' N. 64° 32' W., 8,000 feet wire.

var quadrifilis ?

1 specimen No. 2009 B. O. C. Station 58, 1927. See above.

It is characteristic of all the above recorded specimens that the teeth of the upper jaw are fewer and farther between than are those of the lower jaw.¹⁸ As this is in striking contrast with what seems to be the usual relation in the family Oneirodidae the feature may be added to the diagnosis of the genus.

The numbers of teeth are altogether very small, there being only about 6 to 8 in each side of upper, and about 10 to 11 in each half of lower jaw. The teeth of the lower jaw are long and slender, those of the upper much smaller. There are two teeth behind each other on each side of the vomer.

The following table gives a few measurements of the specimens in millimeters:

	No. 2006	<i>var. quadrifilis.</i>	
		No. 2007	No. 2027
Total length	29	26	25
Length without caudal	24	21	20
Length of lower jaw	11	10	10
Width of head at sphenatics	6	6	6
Length of illicium	7	6	6

¹⁸ This quite agrees with the figure of the type-specimen (Regan 1926 loc. cit. plate VI, fig. 2) showing 8 teeth in upper and 11 teeth in lower jaw. The dentition of the jaws is, however, not mentioned in the description.

The bulb bears a posterior, median, crest-like appendage quite corresponding to the similar development in the *analogus-longicornis* group of the genus *Dolopichthys* (see p. 20). The upper end of the crest is however not pointed but evenly rounded. The clavate distal tubercle is rather produced and pointed and somewhat anterior to the middle of the bulb. Between this tubercle and the crest a single median filament is found.

By the structure of the just mentioned filament on the bulb two different types of the species can easily be distinguished in the material now at hand. In the specimen from Station 48 (No. 2006 B. O. C.) the filament is undivided till considerably above the highest point of the posterior median crest, and then divides into two simple, not bifurcating terminal filaments which are only

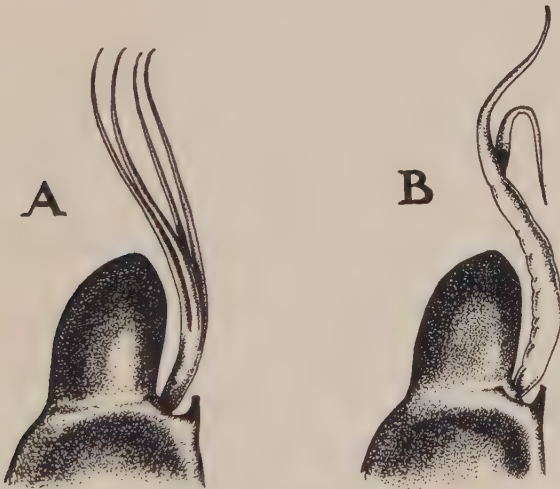


Fig. 8. Distal end of the bulb of *Chaenophryne longiceps* var. *quadrifilis* (A), and *forma typica* (B).

about half as long as the thick, undivided basal part. In two other specimens (Nos. 2007 and 2027 B. O. C.) the filament bifurcates after a very short undivided part, each branch again bifurcating so that four equal, thin, tapering filaments are found. All bifurcations in these specimens take place well below the upper end of the posterior crest, and the terminal filaments are two to three times as long as the undivided part of the appendage. The fourth specimen (No. 2009 B. O. C.) from the same station as No. 2007 has unfortunately lost its entire illicium. As there are no structural indications of gradual variations from one type to another, it is not improbable that they may even be classified as separate species, the material so far examined in this respect is, however, not sufficient to justify this step without further confirmation of the stability of the characters in question.

As Regan in his description only mentions "bulb with a filament"¹⁹ the specimen No. 2006 B. O. C. with the long undivided basal part and the two short terminal filaments can probably be identified with his type-specimens, while the specimens Nos. 2007 and 2027 B. O. C. with four long terminal filaments and a short basal part of the appendage must be described as a new variety—*var. quadrifilis*.

In addition to the special structure of the terminal filament on the bulb, there also seems to be a characteristic tendency towards fewer rays in the dorsal and anal fins in *var. quadrifilis* than in the typical form, only five rays being counted in the dorsal and four to five rays in the anal of the former, which six to seven and five to six rays are found in the latter.

THAUMATICHTHYS Smith and Radcliffe 1912.

Praemaxillaries extending far beyond the lower jaw in front and on the sides, attached to the head by a wide membrane. Eyes close to the angles of the mouth. Lateral line present. No sphenotic, praeopercular or articular spine. Lower part of the body with dermal spines. Illicium projecting from the lower side of the anterior membranous connection between the extended praemaxillaries. Bulb with a small tooth-bearing dermal bone.

This very peculiar genus was originally contributed to a separate family but has later (Regan 1925) been brought into connection with the family Oneirodidae through the recently discovered genus *Lasiognathus* Regan 1925, which agrees with *Thaumatichtys* in the structure of the mouth and in having osseous denticles connected with the bulb, but has the eyes in normal position, well developed sphenotic and articular spines but no spines on the skin, and has a suprarostrol illicium on a long, exerted basal bone.

Key to the species

- A. A pair of long, hinged, movable teeth inserted near the anterior end of each praemaxillary, lying closely applied to the roof of the mouth when depressed. Other teeth on praemaxillaries long and cardiform, several or many times as long as long as the diameter of the eye.²⁰ Throat with dermal spines. Eye 20 in head.²¹ D. 6.

T. pagidostomus Smith and Radcliffe.

- B. No long, specially developed, hinged teeth in praemaxillaries. Longest teeth scarcely equal to the diameter of the eyes. Throat without spines. Eye 8 to 9 in head.²¹ D. 4.....*T. binghami* n. sp.

¹⁹ Regan 1926, loc. cit. p. 31. The posterior crest on the bulb is not mentioned at all, it is, however, roughly indicated in the figure, plate VI, fig. 2.

²⁰ According to figure: Smith, H. M. and Radcliffe, L.: Description of a new family of pediculate fishes from Celebes. Proc. U. S. Nat. Mus. XLII, 1912, Plate 72, fig. 1.

²¹ Measured to the margin of the gill-slits.

Thaumachithys binghami n. sp.

1 specimen No. 2015 B. O. C. Station 25, 17/3, 1927.

24° 51' N. 76° 37' W. 8000 feet wire.

Total length 52 mm. Length without caudal 39 mm. Width of head 11 mm. Height of head 7 mm. Length of lower jaw 8 mm. Point of lower jaw to the edge of the projecting snout 3 mm. Length of the head to the gillslit 17 mm. Diameter of the eye 2 mm. Length of the illicium 3 mm.

The head is broad and depressed, of about the same size as in *T. pagidostomus* when measured to the margin of the gillslit. The lower jaw is rather short, contained nearly five times in the total length without caudal. The eyes are comparatively large, equaling one-ninth to one-eighth of the length of the head.

Illicium is very short, projecting straight forward from the ventral side of the anterior membranous connection between the praemaxillaries. The anterior view of the bulb shows a ventral, transverse dermal keel with the lower lateral angles drawn out into a pair of short, downwards directed tentacles, one on each side. Above the ventral transverse keel follows on each side one simple, wing-like, vertical, lateral crest. In the median of the bulb two small tubercles are found close above each other on the upper half of its anterior surface. On the lower posterior surface of the transverse ventral keel a strongly curved median bone is imbedded in the skin, starting on the lower surface of the bulb itself, then curving down in the posterior surface of ventral keel ending near the margin of the latter with a short, strong, downwardly and backwardly directed denticle.

The ventral and posterior parts of the fish are furnished with minute dermal spines, there are, however, none on the throat before the bases of the pectorals. According to the figures of *T. pagidostomus* the dermal spines are much smaller in *T. binghami* than in the former.

There is a distinct lateral line consisting of small pores connected by a narrow groove, appearing as a very thin line with slight extensions at the pores. The lateral line commences above the eye and runs on the upper part of the body to somewhat in front of the anus, then curves down and runs along the middle of the tail to the base of the caudal fin, where it ends. There are about 35 to 40 pores from above the base of the pectoral fin to the end of the line.

D. 4, A. 4, P. about 18. C. 2 simple rays above + 4 bifid rays + 3 simple rays below.

MELANOCETIDAE

MELANOCETUS Günther 1864.

It appears from the present material that the pigmentation covering the finrays is the last to develop during the growth of the individuals. In the smaller specimens of all species we find entirely colorless fins, while the body is already densely pigmented. It further seems that the stage (size) at which the pigment starts developing on the fins is sufficiently different in the different species to



Fig. 9. *Thaumatoichthys binghami* n. sp. Ventral and lateral view of the fish and frontal view of the bulb. Drawn by W. S. Bronson.

be a valuable help in determining young individuals. In *M. niger* Regan 1925 the caudal rays are already entirely black at a total length of 19 mm. In *M. murrayi* Günther 1887, the caudal finrays have only a little pigment at their base, the fin still being practically entirely white at a total length of 23 mm. At a total length of 30 mm. the caudal rays of this species are also entirely black while a specimen of *M. Johnsoni* Günther 1864, 35 mm. long, has no pigmentation at all on the fins.

A good synopsis of the species is given by Regan 1926, loc. cit. p. 32. The new species of the Bingham Oceanographic Collection, *M. tumidus*, is characterized by a lower jaw which is less than half of the total length without caudal, by a very short illicium only equaling about 1/6 of the same measure and by the very small teeth, the longest of which are only 1/5 to 1/4 of an eye-diameter, while in all other species the longest teeth (in the lower jaw) are longer than the diameter of the eyes. In the identification of the species *M. Murrayi* Günther and *M. Johnsoni* Günther, Regan's descriptions (1926) have been followed.

Melanocetus Murrayi Günther 1887

1 specimen No. 2023 B. O. C. Station 11, 2/3, 1927.

23° 58' N. 77° 26' W. 7000 feet wire.

3 specimens Nos. 2017 and 2021 B. O. C. Station 16, 9/3, 1927.

23° 49' N. 76° 58' W. 7000 feet wire.

1 specimen No. 2014 B. O. C. Station 18, 10/3, 1927.

23° 42' N. 76° 43' W. 7000 feet wire.

1 specimen No. 2018 B. O. C. Station 22, 12/3, 1927.

23° 37' N. 77° 15' W. 7000 feet wire.

1 specimen No. 2019 B. O. C. Station 33, 22/3, 1927.

24° 11' N. 75° 37' W. 8000 feet wire.

2 specimens No. 2016 B. O. C. Station 39, 29/3, 1927.

22° 43' N. 74° 23' W. 8000 feet wire.

1 specimen No. 2020 B. O. C. Station 58, 20/4, 1927.

32° 24' N. 64° 29' W. 10,000 feet wire.

The following table gives some of the proportions measured in the present material of this species:

	Length without caudal mm.	Lower jaw	Illicium	Inter- orbital width ²²	Post orbital width ²³	Length of C.	Length of P.	Longest ray of D.
		in percent of the total length without caudal fin.						
No. 2019 B. O. C.	115	40	23	10	23	27	10	19
No. 2014 B. O. C.	60	50	30	15	28	28	13	20

²² Between edges of frontals.

²³ Between edges of sphenotics.

	Length without caudal mm.	Lower jaw	Ill- cium	Inter- orbital width ²²	Post orbital width ²³	Length of C.	Length of P.	Longest ray of D.
	in percent of the total length without caudal fin.							
No. 2017 B. O. C.	{ 47	47	30	15	30	28	17	19
	{ 44	50	30	15	31	30	—	20
No. 2018 B. O. C.	37	53	30	15	35	35	16	19
No. 2020 B. O. C.	25	48	30	16	32	32	16	19
No. 2021 B. O. C.	23	44	26	15	30	28	13	20
No. 2016 B. O. C.	17	47	23	—	—	35	15	18
No. 2023 B. O. C.	15	53	30	—	—	37	—	20
No. 2016 B. O. C.	12	50	29	—	—	42	—	21

In the two smallest specimens (total lengths 17 and 20 mm.) the fins are still uncolored, in the biggest of the two a black pigment has, however, started to develop at the base of the caudal rays. In all the larger specimens the caudal finrays are entirely black.

Melanocetus tumidus n. sp.

1 specimen No. 2022 B. O. C. Station 11, 2/3, 1927.

23° 58' N. 77° 26' W. 7000 feet wire.

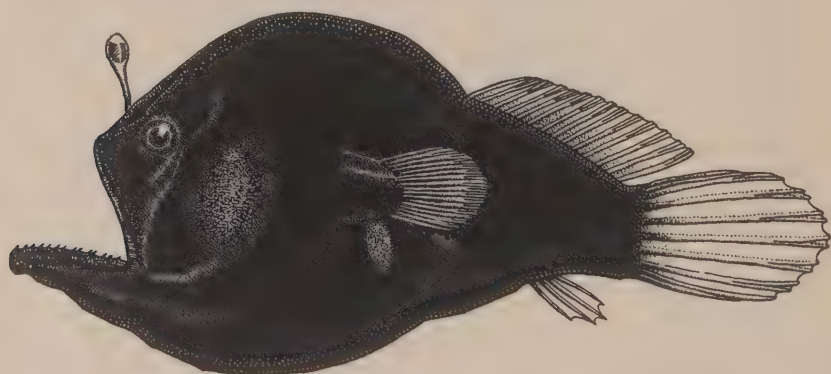


Fig. 10. *Melanocetus tumidus* n. sp. Drawn by W. S. Bronson.

Total length 21 mm. Length without caudal 15 mm. Lower jaw 6 mm. Illicium 2.5 mm. Eye about 1.25 mm. Width of head between edges of sphenotics 4.5 mm.

The width between the edges of the frontals is about half of the postorbital width between the edges of the sphenotics. The mouth is rather small, lower jaw 2.5 in length without caudal.

Illicium very short, only 1/6 of the length without caudal. Bulb small, occupying about one-third of the total length of the illicium.

There are no enlarged fangs. All the teeth are very small, the longest ones only attaining a length of about $1/5$ to $1/4$ of the diameter of the eye. One tooth on each side on the vomer.

The vertical fins and the stem of illicium white, there are, however, already a few dots of black pigment on the rays of the caudal fin, visible under a lens.

D. 14. A. 4. P. 18. V. 1 simple ray above + 6 bifid rays + 2 simple rays below.

Melanocetus johnsoni Günther 1864

1 specimen No. 2024, B. O. C. Station 52, 11/4, 1927.

21° 30' N. 71° 11' W., 8000 feet wire.

Total length 35 mm. Length without caudal 25 mm. Lower jaw 14 mm. Illicium 10 mm. Width between edges of frontals 5 mm. Postorbital width between the edges of the sphenotics 8 mm. Length of pectoral rays 5 mm. Longest ray of dorsal fin 6 mm. Caudal fin 10 mm.

In addition to the other differences between *M. murrayii* and *M. johnsoni*, the latter also seems to be distinguished by considerably longer fins than the former. In the present specimen of *M. johnsoni* the length of the caudal is 40 percent, the pectoral 20 percent, and the longest ray of the dorsal fin 24 percent of the total length without caudal (compare with the measurements of *M. murrayii* p. 27-28).

All fins and the stem of the illicium are still entirely colorless.

Melanocetus niger Regan 1925.

1 specimen No. 2025 B. O. C. Station 25, 17/3, 1927.

24° 51' N. 76° 33' W. 8000 feet wire.

1 specimen No. 2026 B. O. C. Station 56, 13/4, 1927.

21° 20' N. 71° 13' W., 6500 feet wire.

In the smallest specimen (No. 2026 B. O. C.) which is only 16 mm. long (total length) the dorsal and anal fin is still white, but several of the caudal rays are already covered by black pigmentation for nearly half their length. In the other specimen, which is a little larger, measuring 19 mm. total length, the caudal rays are entirely black and the pigment is starting to develop from the bases of the dorsal and anal rays.

CERATIIDAE

Cryptosparas couesii Gill 1883.

1 specimen No. 2002 B. O. C. Station 23, 14/3, 1927

24° 29' N. 77° 29' W., 8000 feet wire

Total length 38 mm.

1 specimen No. 2003 B. O. C., Station 25, 17/3, 1927.

24° 51' N. 76° 38' W. 8000 feet wire.

Total length 34 mm.

Mancalias uranoscopus Murray 1878.

1 specimen No. 2004 B. O. C., Station 39, 29/3, 1927.

22° 43' N. 74° 23' W. 8000 feet wire.

Total length 49 mm.

ACERATIDAE

Key to the Genera²⁴

- A. No rostral denticles. Praemaxillaries meeting dentaries when mouth is closed.....*LIPACTIS* Regan 1925.
- B. A group of rostral denticles in front of the praemaxillaries meeting the anterior teeth of the lower jaw.
 - I. Eyes telescopic.....*ACERATIAS* Brauer 1902.
 - II. Eyes not telescopic.
 - a. Snout compressed and pointed in vertical view²⁵ Nostrils lateral, nasal laminae longitudinal. Mouth longitudinal.
RHYNCHOCERATIAS Regan 1925.
 - b. Snout and head very broad, somewhat depressed. Nostrils dorsal, nasal laminae transversal. Mouth transversal.
LAEVOCERATIAS n. gen.

RHYNCHOCERATIAS Regan 1925.

Characters as above described. As the figures of two of Regan's four species (viz: *R. oncorhynchus* and *R. rostratus*, figs. 3 and 4, plate XIII, Regan 1926, loc. cit.) plainly indicate the presence also in these species of spines along the dorsal profile of the snout similar to those found in both species of the present collection, it seems possible that this feature upon a closer examination will appear to be a common character of the genus. The spines are, however, not mentioned in any of the descriptions given by Regan.

Key to the species

- I. Anterior nostrils at the end of the snout, narrowly separated. Posterior nostrils contiguous to the eyes. Nostrils very large. Rostral projection short, with a single series of teeth. D. 4-5, A. 4. *R. leucorhinus* Regan 1925.
- II. Anterior nostrils not at the end of the snout.
 - A. Nostrils moderate, the posterior well separated from and smaller than the eyes. D. 4-5, A. 4.
 - 1. Rostral projection short, with denticles in a single series. Depth of body about $2\frac{1}{3}$ in length.....*R. brevirostris* Regan 1925.
 - 2. Rostral projection long, with denticles in a group. Depth of body about $3\frac{1}{2}$ in length.....*R. oncorhynchus* Regan 1925.

²⁴ Representing the synopsis given by Regan 1926 loc. cit. p. 43, adapted to embrace also the new genus *Laevocerantias*.

²⁵ The swollen nasal bulbs being left out of consideration.

B. Nostrils large, the posterior near or contiguous to the eyes and about equal to or larger than the eyes in vertical diameter.

1. D. 5. A. 4. Rostral denticles in a group. Profile of the snout equally curved.....*R. rostratus* Regan 1925.

2. About 8 or more rays in the dorsal fin.

a. Profile of the snout descending in an equal curve. Rostral denticles in an outer, marginal and an inner transverse series.....*R. acanthirostris* n. sp.

b. Snout very high, anterior profile nearly vertical, joining the upper profile at a rounded angle which is higher than the profile of the interorbital space. Rostral denticles in an irregular group.....*R. latirhinus* n. sp.

Rhynchoceratis acanthirostris n. sp.

1 specimen No. 2011 B. O. C. Station 22, 12/3, 1927.

23° 37' N. 77° 15' W. 7000 feet wire.

Total length 28 mm. Length without caudal 20 mm. Greatest height 5.5 mm. Height of head 5 mm. Width of head 4.5 mm. Snout to gill-opening 9 mm. Snout to eye 3 mm. Length of mouth-left ab. 2.5 mm. Diameter of eye ab. 1.5 mm.

Length of head to gill-opening nearly half of the total length without caudal. The upper profile of the head is gradually descending towards the equally curved outline of the snout. The length of the snout from the eyes equals about two eye-diameters.

There is a median series of 4 small, but sharp and strong spines along the dorsal ridge of the snout, directed downwards and forwards. A fifth smaller spine belonging to the same series is found in an erect position just above the bases of the rostral denticles.

The rostral denticles are arranged in an outer series around the margin, with about four teeth on each side, and an inner, transverse series with four small denticles altogether.

The nostrils are very large, the posterior about twice as big as the anterior, contiguous to and somewhat larger than the eyes in vertical diameter. The distance from the end of the snout to the anterior nostrils is somewhat longer than the diameter of the eyes. The region between the nostrils is uncolored.

The length of the caudal fin is contained 2.5 times in the length of the fish without caudal, and is slightly shorter than the distance from the snout to the gill-openings.

D. 2 vestigial + 8 normal rays. A. 3 normal + 1 vestigial ray. P. 16. C. 2 simple rays above + 5 bifid rays + 1 simple ray below.

Rhynchoceratis latirhinus n. sp.

1 specimen No. 2012 B. O. C. Station 33, 22/3, 1927.

24° 11' N. 75° 37' W. 8000 feet wire.



Fig. 11. *Rhynchoceratias acanthirostris* n. sp. Lateral view of the entire fish and dorsal view of the snout. Drawn by W. S. Bronson.



Fig. 12. *Rhynchoceratias latirhinus* n. sp. Lateral view of the entire fish and dorsal view of the snout. Drawn by W. S. Bronson.

Total length 22 mm. Length without caudal 15 mm. Greatest height 4.5 mm. Height of head 4.5 mm. Width of head 3.5 mm. Snout to gill opening 8 mm. Snout to eye 3 mm. Cleft of mouth 2 mm. Diameter of eye 1.5 mm.

Length of the head to the gill opening slightly more than half of the total length without caudal. Head rather narrow, its upper profile deeply concave, ascending again towards the very high snout, the anterior profile of which is nearly vertical.

The upper $3/5$ of the anterior edge of the snout with a median series of 5 small nearly erect spines, lower $2/5$ smooth.

The rostral denticles in an irregular group.

The nostrils are very large, the posterior twice as large as the anterior, contiguous to the eyes and of about the same size in vertical diameter. The anterior nostrils are well separated from the anterior edge of the snout.

Lower jaw with a transverse ridge just behind the teeth fitting into a transverse groove behind the rostral denticles. Rostrum slightly prominent.

Black pigment scanty on the fins. The region between the nostrils is uncolored (white).

D. 10. A. 3. P. 17, C. 1 simple ray above + 6 bifid rays + 2 simple rays below. The seven posterior rays of the dorsal fin are normal, anteriorly the fin is somewhat damaged and three articulated rays of the same thickness as the others, but shorter and peculiarly curved forwards, protrude through the opening in the skin. These short rays probably are remnants of normal rays which have been torn, it is, however, not quite impossible that they may be specially differentiated in this species.

LAEVOCERATIAS n. gen.

A group of rostral denticles at the end of the snout, which is, however, not produced or compressed but very broad and short. Head very broad, broader than high and much broader than the body. Nostrils moderate, not lateral but dorsal, with transverse nasal laminae. Nasal region not swollen. Eyes normal.

One species.

Laevoceratias liparis n. sp.

1 specimen No. 2013 B. O. C. Station 33, 22/3, 1927.

24° 11' N. 75° 37' W. 8000 feet wire.

Total length 23 mm. Length without caudal 17 mm. Snout to gill opening 7.5 mm. External width of head 7 mm. Width of skull about 5 mm. Height of the head (greatest height of fish) 5 mm. Width of mouth-opening 2.5 mm.

The head is very broad, nearly circular in vertical view, somewhat depressed with a nearly flat dorsal surface. The mouth is small and transversal, nearly straight, at the end of the snout. The snout is not produced, narrowed or compressed, but short and very broad, evenly rounded.

There are three long, thin, curved and depressible rostral denticles, opposed

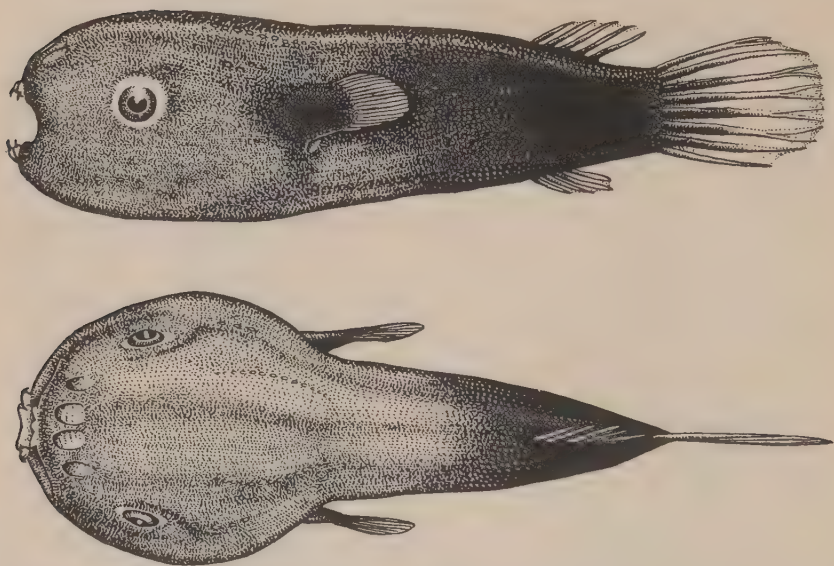


Fig. 13. Lateral and dorsal view of *Laevoceratias liparis* n. sp. Drawn by W. S. Bronson.

to four similar teeth at the end of the lower jaws. Each of these denticles, both on rostrum and in lower jaw, protrude from a small, separate, white, wart-like elevation of the skin. The arrangement of these white warts gives the end of the snout a conspicuous and characteristic appearance.

The nostrils are moderate, placed beside (not in front of) each other on the upper horizontal surface of the head. The nasal laminae are transversal, the nasal region not swollen.

D. 5. A. 4. C. from above: 1 bifid + 1 simple + 4 bifid + 2 simple rays.

SCIENTIFIC RESULTS OF THE THIRD OCEANOGRAPHIC
EXPEDITION OF THE "PAWNEE"
1927

DEEP SEA EELS, EXCLUSIVE OF LARVAL FORMS

BY ALBERT EIDE PARR

Curator of the Bingham Oceanographic Collection

INTRODUCTION

The present article is the fifth in a series of reports dealing with the fishes collected during the third oceanographic expedition of the Pawnee, in 1927, under the direction of Harry Payne Bingham.

While the material of deepsea eels, in proportion to the abundance of many of the other systematic groups in the same collection, may be said to be relatively scanty, it is nevertheless of a very considerable systematic interest, having been found to include four new species and various samples of previously known forms which may serve to alter the current conception of their taxonomic status. Both the demersal (*Congridae*, *Synaphobranchidae* and *Ilyophidae*) and the bathypelagic (*Nemichthyidiformes*) groups are represented, the former being obtained on the two occasions when accidental (Station 54) or intentional (Station 20) contact was made with the bottom during the operation of the trawls.

NEW SPECIES

Ariosoma perturbator n. sp.

Platuronides ophioccephalus n. sp.

Platuronides acutus n. sp.

Avocettina exophthalma n. sp.

•

STATION LIST

STATION 5. February 26, 1927. 25° 56' N. 77° 37' W. 5000 feet wire.

2 *Serrivomer sector* Garman.

STATION 9. March 1, 1927. 23° 55' N. 77° 09' W. 4000-7000 feet wire.

1 *Serrivomer sector* Garman.

STATION 18. March 10, 1927. 23° 42' N. 76° 43' W. 7000 feet wire.

1 *Avocettina exophthalma* n. sp.

STATION 20. March 11, 1927. 23° 54' N. 77° 09' W. 710-720 fathoms depth.
Ottertrawl.

1 *Ariosoma perturbator* n. sp.

1 *Ilyophis brunneus* Gilbert.

10 *Synaphobranchus pinnatus* (Gronov).

STATION 22. March 12, 1927. 23° 37' N. 77° 15' W. 7000 feet wire.

1 *Serrivomer sector* Garman.

STATION 23. March 14, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.

1 *Labichthys carinatus* Gill and Ryder.

STATION 39. March 29, 1927. 22° 43' N. 74° 23' W. 8000 feet wire.

1 *Serrivomer sector* Garman.

1 *Avocettina infans* Günther?

STATION 48. April 4, 1927. 21° 44' N. 72° 43' W. 7000 feet wire.

1 *Avocettina infans* Günther?

STATION 54. April 12, 1927. 21° 16' N. 71° 17' W. 7500 feet wire. 900-955 fathoms depth.

8 *Synaphobranchus pinnatus* (Gronov).

STATION 58. April 20, 1927. 23° 24' N. 64° 29' W. 10,000 feet wire.

1 *Nessorhamphus ingolfianus* Schmidt.

2 *Serrivomer* sp.

1 *Platuronides ophioccephalus* n. sp.

1 *Platuronides acutus* n. sp.

STATION 59. April 21, 1927. 32° 19' N. 64° 33' W. 8000 feet wire.

2 *Serrivomer sector* Garman.

1 *Serrivomer* sp.

SYSTEMATIC ACCOUNT

Family NEMICHTHYIDÆ

Genus **Serrivomer** Gill and Ryder

See under genus *Platuronides*

Serrivomer sector Garman 1899

Serrivomer sector Roule and Bertin 1929, p. 36.

2 specimens, No. 2727 B. O. C. Station 5, February 26, 1927. N. 25° 55' 50".
W. 77° 36' 45". 5000 feet wire out.

1 specimen, No. 2728 B. O. C. Station 9, March 1, 1927. N. 23° 55' 25".
W. 77° 09' 10". 4000-7000 feet wire out.

1 specimen, No. 2729 B. O. C. Station 22, March 12, 1927. N. 23° 37' 25".
W. 77° 15' 20". 7000 feet wire out.

1 specimen, No. 2730 B. O. C. Station 39, March 29, 1927. N. 22° 42' 33'.
W. 74° 23'. 8000 feet wire.

2 specimens, No. 2731 B. O. C. Station 59, April 21, 1927. N. 32° 19' 18".
W. 64° 32' 30". 8000 feet wire.

The collection does not afford sufficient material for comparison to make it possible to differentiate the specimens on hand with reference to the subspecies proposed by Roule and Bertin or to enable one to consider the validity of these subspecific distinctions. The sample from station 5 (No. 2727 B. O. C.) might perhaps pertain to subspecies *brevidentatus*.

Incertae sedis

2 specimens, No. 2733 B. O. C. Station 58, April 20, 1927. N. 32° 24' 15".
W. 64° 29'. 10,000 feet wire out.

1 specimen, No. 2732 B. O. C. Station 59, April 21, 1927. N. 32° 19' 18".
W. 64° 32' 30". 8000 feet wire out.

The above specimens, which are all relatively small, combine a vomerine dentition more or less similar to that of *Platuronides acutus* with vertical fins of the type characteristic of *Serrivomer*. Due to the partly damaged state of the larger one of these specimens (No. 2732 B. O. C., 170 mm.) and the very small size of the other two, the author has not felt justified to assign any separate taxonomic status and designation to the species they might represent. The distinction between the genera *Platuronides* and *Serrivomer* is apparently further obscured (see below) by the features of this intermediate form or stage.

Genus *Platuronides* Roule and Bertin 1929

According to the original definition, the genus *Platuronides* should differ from *Serrivomer* in two respects: (1) by the shape of the most posterior portions of dorsal and anal fins, which together with the rudimentary true caudal fin form a semi-rhombic pseudo-caudal, and (2) by the vomerine dentition, which in *Platuronides* should consist of a single series of widely separated, pointed and conical teeth, as compared with the compressed and lanceolate teeth of *Serrivomer*, which are inserted in two alternating series at the median so closely together as to give the appearance of a continuous, serrate, vomerine keel. While both of the new species to be described below show perfect agreement with the genus *Platuronides* on the first of these two points, the vomerine dentition is, on the other hand, decidedly intermediate in one, and very close to the typical dentition of *Serrivomer* in the other of these forms. With the distinction between the two genera thus reduced to a mere difference in the outlines of the fins surrounding the distal part of the tail, the author was at first inclined to synonymize *Platuronides* with *Serrivomer*. A closer inspection has, however, revealed certain features in the arrangement of the vertical fins, correlated with the development of the pseudo-caudal, which can be expressed numerically and are therefore better adapted for a sharp definition of generic distinctions. It is characteristic both of *Serrivomer* and *Platuronides* that the rays in the most anterior portions of the vertical fins are somewhat more closely spaced than in

the midsection of the fish and that there is again a gradual concentration of the rays towards the end of the tail. In *Platuronides* the ultimate caudal concentration of rays is much greater and affects a much larger number of rays than in *Serrivomer*, and this density of rays in the former genus also explains the relative erectness and rigidity of the pseudo-caudal section of its vertical fins as compared with the laxity of the same parts in *Serrivomer*. The following table shows the average spacing of the vertical fin rays in the various parts of the fins in *Platuronides* and *Serrivomer*. Average space per ray refers to the space occupied by the base of the ray itself plus the distance to the next ray, or, if preferable, to the distance between the centers of the rays.

SPACING OF VERTICAL FIN RAYS IN *Platuronides* AND *Serrivomer*

<i>Platuronides ophiocephalus</i>				<i>Serrivomer sector</i>	
Dorsal fin		Anal fin		Anal fin	
Rays number	Average space per ray ¹	Rays number	Average space per ray ¹	Rays number	Average space per ray ¹
1-30	0.50	1-30	0.52	1-14	0.54
30-50	0.46	30-50	0.56	14-24	0.85
50-70	0.55	50-80	0.69	24-44	0.80
70-90	0.62	80-100	0.65	44-64	0.70
90-110	0.50	100-120	0.40	64-84	0.48
110-125	0.35	120-130	0.17	84-104	0.17
125-140	0.20	Last 50-55	0.07	Last 20 rays	0.09
Last 45-50 (No. 140 to end of fin)	0.09	(No. 130 to end of fin)		(No. 104 to end of fin)	
Total space occupied by first 100 rays:	52.3 ¹		59.4 ¹		64.8 ¹
Approximate number of rays within last 3.5 per cent of the total length (excl. of caudal fin).		50		30	

It may be seen from this table that, while more than 50 of the most posterior rays in the anal fin of *Platuronides* occupy a space per ray of less than one-

¹ All measurements in per cent of the total length of the entire fish, not of the vertical fins alone.

tenth of one per cent of the total length of the fish, only about 20 of the ultimate anal rays in *Serrivomer* show a similar concentration. As the most practical way of utilizing the feature for taxonomic differentiation may be recommended that the last 3.5 per cent of the total length of the fish be marked off on the specimen and that the numbers of rays within this section be counted and compared with the figures for each of the two genera, which may differentiate as follows:

1. Posterior portions of dorsal and anal fins with densely crowded rays, relatively rigid. About 50 anal rays in the last 3.5 per cent of the total length of the fish, and more than 50 rays occupying a space per ray of less than one-tenth of one per cent of the total length.

Platuronides Roule and Bertin

2. Posterior portions of dorsal and anal fins lax, not forming a pseudo-caudal. Only about 30 anal rays in the last 3.5 per cent of the total length of the fish, and only about 20 rays occupying a space per ray of less than one-tenth of one per cent of the total length. *Serrivomer* Gill and Ryder

Key to the genus *Platuronides*

- I. Vomerine teeth all conical and widely separated. Anterior nostril tubular.
P. danae Roule and Bertin 1929, p. 48
- II. Posterior vomerine teeth compressed, not widely separated. Anterior nostril not tubular.
 - A. Anterior portion of vomer with only two series of teeth. Teeth in posterior portion strongly compressed and very wide. Vomerine projection beyond the attachment of the maxillaries only about one-sixth of the entire length of the snout. Width between sphenotic prominences less than 20 per cent greater than the interorbital width.
P. ophiocephalus n. sp.
 - B. Anterior portion of vomer with an irregular band of small teeth, about 4-6 wide. Teeth in posterior portion moderately wide and compressed. Vomerine projection beyond the attachment of the maxillaries about one-third of the entire length of the snout. Width between sphenotic prominences about 40 per cent greater than interorbital width.

P. acutus n. sp.

Platuronides ophiocephalus n. sp.

- 1 specimen, No. 2725 B. O. C. (TYPE). Station 58, April 20, 1927. N. 32° 24' 15". W. 64° 29'. 10,000 feet wire.

Orbital and postorbital parts of the head almost rectangular in cross section, with a flat dorsal surface, and flat vertical sides, joining along a fairly well marked edge supported by the upper skeletal rim of the orbit in front and by the sphenotic prominence farther back (see fig. 1). Only the lower surface rounded. Eyes entirely lateral, somewhat elliptic, their vertical diameter only

about four-fifths of their horizontal diameter, which is contained a little over four times in the length of the snout and about $13\frac{1}{2}$ times in the entire length of the head. Dorsal profile of the head practically straight. Snout gradually tapering to a blunt point both in dorsal and lateral views. Width between

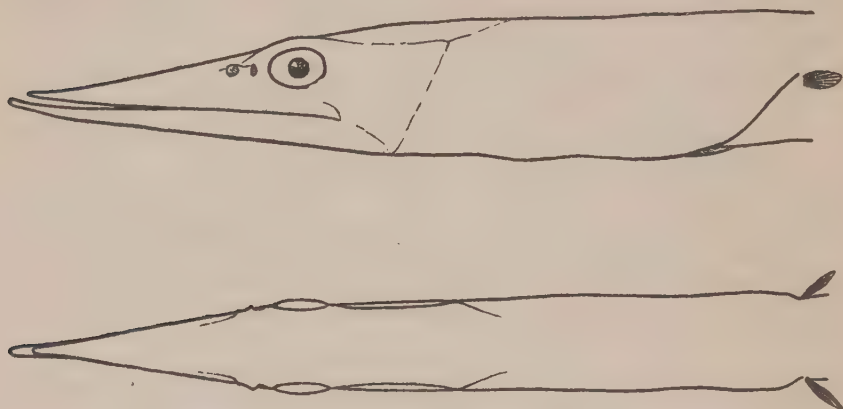


Figure 1. Head of *Platuronides ophiocephalus* n. sp. in lateral view (above) and dorsal view (below).

sphenotic prominences only very inconspicuously greater than interorbital width. Vomerine projection beyond the attachments of the maxillaries relatively very short, only about one-sixth of the entire length of the snout¹ (see fig. 2). Cleft of mouth extending only very slightly beyond the posterior margin of

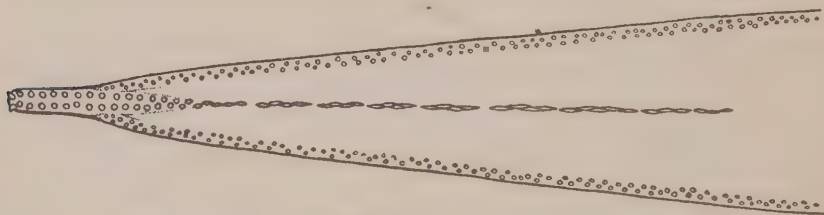


Figure 2. Upper dentition in *Platuronides ophiocephalus* n. sp.

the eye. Lower jaw prominent, reaching well beyond the point of the snout. Nostrils not tubular. Distance from anterior nostril to anterior margin of the eye opening about equal to half of the horizontal diameter of the latter. The branchial cavity occupies about half of the entire length of the head. Gillslit

¹ The point of the snout is somewhat broken, but all the parts appear to be there and have been included in the measurements.

strongly oblique and very long, its length about equal to the greatest depth of the head, although its upper end only reaches to the middle of the side. Origin of dorsal somewhat behind the origin of anal fin. Caudal fin and pseudo-caudal sections of dorsal and anal fins as in *P. danae*. Pectorals very small, at the upper end of the gillslits. For the arrangement of the finrays see table and text on pages 3-4, while further measurements are included in the table rendered herewith.

MEASUREMENTS OF *Platuronides*

Species		<i>P. ophiocephalus</i>	<i>P. acutus</i>
Total lengths in mm.		632	220
Length of head		16.3	15.5
Length of snout		5.0	5.5
Snout to sphenotic prominence		8.9	9.1
Postorbital length of head		10.4	8.7
Cleft of mouth ¹		6.5	6.6
Lower jaw		8.0	7.7
Interorbital width	In	1.6	1.3
Sphenotic width	per cent	1.8	1.8
Depth of head	of total	2.8	2.3
Greatest depth	length	4.7 ²	2.5
Gill slit		2.9	2.4
Vomerine projection		0.85	1.8
Horizontal diameter of eye		1.2	0.9
Snout to D.		31.0	32.0
Snout to A.		25.6	25.0
P to D		14.5	17.0
P to A		10.0	9.7

¹ From snout.² Belly expanded by spawn.

Dentition. The anterior portion (head) of the vomer carries only two, somewhat irregular rows of relatively large, conical and slightly decurved teeth, about 15-16 in each row, while the posterior portion has a long double series of alternating, strongly compressed and lanceolate teeth, very similar to the vomerine teeth of *Serrivomer* both in shape and in the compactness of their arrangement. This posterior vomerine dentition differs from that of the latter genus, however, in that the series is not continuous but broken up into about 6-8 separate groups of about 4-6 teeth each. This group formation is particularly distinct around the beginning of the last third of the length of the entire series, with each group forming a natural unit of gradually smaller teeth in front of and

behind one, or a few, larger ones in their middle (see fig. 3). The vomerine dentition reaches approximately to the region of the anterior margins of the eyes. There is an irregular double row of small conical teeth in each jaw.

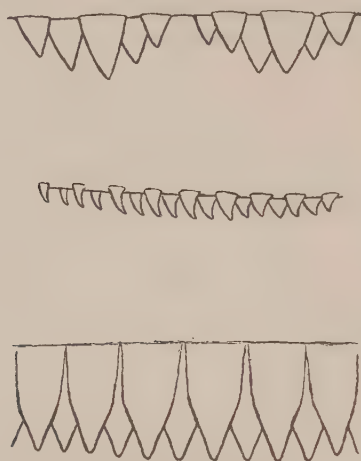


Figure 3. Top to bottom: Vomerine dentition in *Platuronides ophioccephalus* (part), *Platuronides acutus* (entire dentition), and *Serrivomer* sector (part).

D. 185-190. A. 180-185. P. 6-7.

The specimen is a female with the belly greatly expanded by eggs obviously ripe for extrusion. Color uniform brownish black.

***Platuronides acutus* n. sp.**

1 specimen, No. 2726 B. O. C. (TYPE.) Station 58, April 20, 1927. N. 32° 24' 15". W. 64° 29'. 10,000 feet wire.

Head less compressed than in *P. ophioccephalus*. Eyes entirely lateral, elliptic, their vertical diameter only about four-fifths of their horizontal diameter, which is contained about 6 times in the length of the snout and about 16 times in the entire length of the head. Dorsal profile of the head somewhat concave, with the snout pointing obliquely upward in a slight arch. Snout narrow and sharply pointed. Width between sphenotic prominences very conspicuously (about 40 per cent) greater than the interorbital width. Vomerine projection beyond the attachment of the maxillaries relatively long, representing about one-third of the entire length of the snout. Cleft of mouth extending slightly beyond posterior margin of eye. Lower jaw prominent, reaching well beyond the point of the snout. Nostrils not tubular, situated as in *P. ophioccephalus*. Gillslit strongly oblique and very long, its length about equal to the greatest

depth of the head. Origin of dorsal behind origin of anal fin. Pectorals very small, at the upper ends of the gillslits. Pseudo-caudal sections of dorsal and anal fins with a less distinctly differentiated outline than in *P. danae* and *P. ophiocephalus*, but still recognizable by direct comparison with representatives of *Serrivomer*, and by the arrangement of the finrays, which is entirely identical



Figure 4. Head of *Platuronides acutus*, n. sp. in lateral view (above) and dorsal view (below).

with that of *P. ophiocephalus* (see page 4), with the last 50 anal rays each occupying only about 0.07 per cent of the total length of the fish. Further details concerning the proportions of the type specimen are given in the table of measurements on page 7.

It has been found practically impossible to make an accurate total count of numbers of rays in the vertical fins, but the figures obtained from sectional counts and measurements would indicate that the totals must be practically identical with those of *P. ophiocephalus*, viz. D about 185-190. A. about 180-185.

Anterior portion (head) of vomer with a band of numerous small, irregularly scattered, conical teeth, about 5 or 6 wide at the broadest part, with the teeth nearest to the median somewhat larger than the others. Posteriorly these teeth become gradually larger and more compressed, and continue as a double row of alternating, compressed and somewhat decurved teeth on the shaft of the vomer. There are about 40-60 teeth in a longitudinal count on the anterior part of the vomer, depending upon the manner in which they are counted, and the posterior row on the shaft has about 8-9 teeth on each side of the median. While the latter are larger than the conical teeth on the anterior portion, they are not so large, nor quite so broad and compressed, as those of *P. ophiocephalus*

or of *Serrivomer*, and their free portions do not overlap in the lateral view to nearly the same extent as in the latter forms. The anterior conical dentition also extends much farther backward in *P. acutus*, so that the posterior compressed series is relatively much shorter than in *P. ophiocephalus* (compare figs.

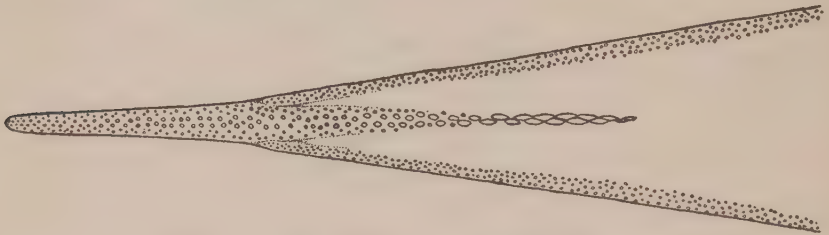


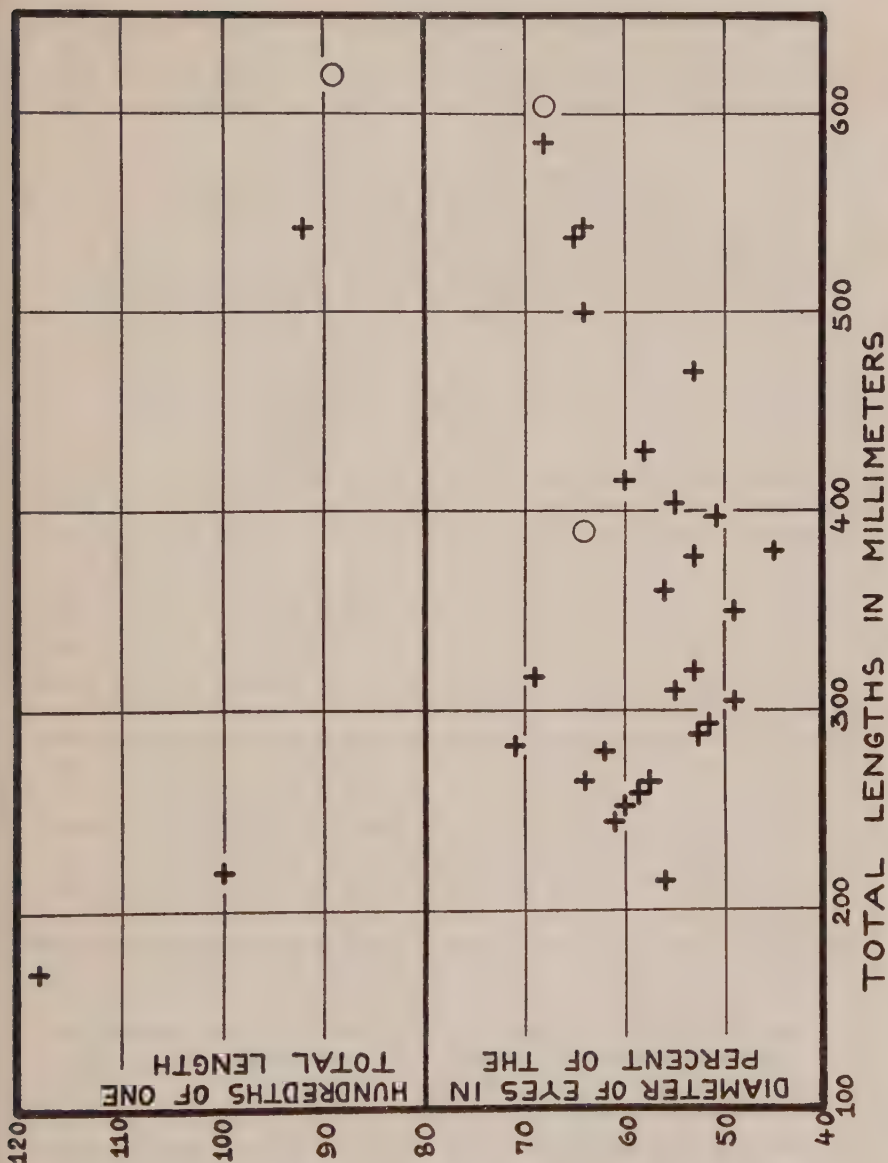
Figure 5. Upper dentition in *Platuronides acutus*, n. sp.

2 and 5), although the vomerine dentition reaches almost to the eyes in both. The maxillaries and dentaries also each carry a band of irregularly scattered, small, conical teeth, 4-6 teeth wide.

Genus **Avocettina** Jordan and Davis

In their monograph of the Nemichthyiformes Roule and Bertin (1929, p. 23) have identified all previously described species pertaining to this genus under the name of *A. infans* Günther. Among the three specimens now at hand, however, two morphologically so very different forms are found that the writer, in spite of the very small material, feels quite unable to entertain any serious doubts about these two forms being also taxonomically perfectly distinct from each other. This conclusion naturally led to a study of the data rendered by Roule and Bertin in favor of their unspecific conception of the genus *Avocettina*.

The two forms present in the collections here reported upon are mainly distinguished by the very different sizes of their eyes, the different widths of their interorbital spaces and the different profiles of their heads. It is unfortunate that no record is made of the interorbital widths in the specimens discussed by Roule and Bertin, nor is any description rendered of the profile of their heads. In their table of measurements (Roule and Bertin, op. cit., p. 26), however, we find a full account of the absolute dimensions of the eyes in 30 investigated specimens. For purpose of analysis the length of the diameter of the eyes can be conveniently expressed in two different relative values: (1) in thousandths of the total length; (2) in fractions of the postorbital length of the head, i. e., in the distance from the posterior margin of the orbit to the top of the gill opening. In the accompanying diagram the diameter of the eyes in thousandths of the total length has been plotted against the latter measurement to show the possible significance of any correlation, which might be found between these two features,



for the question of the existence of taxonomically distinct forms within the material. This illustration is supplemented by the following table giving the correlation between the relative values for the size of the eyes in proportion to the total length of the fish and in proportion to the postorbital length of the head.

SIZE OF EYES IN *Avocettina*

Diameter of eyes in tenths of one per cent of total length	Diameter of eyes in fractions of postorbital length of head									
	2.01 -2.50	2.51 -3.00	3.01 -3.50	3.51 -4.00	4.01 -4.50	4.51 -5.00	5.01 -5.50	5.51 -6.00	6.01 -6.50	
4.50										1
4.51-5.00						1		1		
5.01-5.50					1	4	1	1		
5.51-6.00					2	4	2			
6.01-6.50		1+1	2			2				
6.51-7.00			1+1		1					
7.01-7.50			1							
7.51-8.00										
8.01-8.50										
8.51-9.00	1*									
9.01-9.50	1*									
9.51-10.00					1*					
10.01-10.50										
10.51-11.00										
11.01-11.50										
11.51-12.00	1*									

The observations made on the material now at hand have been entered in the diagram by small circles, and in the table by a plus and a figure in italics. The other values have all been estimated from the measurements rendered by Roule and Bertin. It is now immediately apparent from the figure that the material investigated by the latter authors may well have contained two entirely distinct forms, separated from each other by a wide gap in point of the relative size of their eyes. It is also clearly shown that this difference cannot simply be ascribed to differences in size, because it is also found by a comparison between specimens

of the same length. And it may finally be noticed that the differences indicated in Roule and Bertin's measurements are in perfect accordance with, and even more distinct than, the difference between the two forms observed in the collections now at hand. The table of correlated proportions between eyes and total length, and eyes and postorbital length of the head confirms the existence of two separate groups, and might perhaps even suggest the possible presence of a third form, inasmuch as the recorded postorbital length of the head in Roule and Bertin's specimen no. 28 (marked by *' in the table) is relatively very much greater (4.4 per cent of total length) than the maximum (3.1 per cent of total length) for the entire rest of the material. This exceptionally great postorbital length in this large-eyed specimen causes its isolated position in the correlation table by raising the numerical value of the ratio eye: postorbital length to an exceptional figure for eyes of this size. The measurements rendered by Roule and Bertin are, thus, far from bearing out these authors' own contention of morphological continuity and taxonomic identity within the material studied by them.

This observation, however, does not bear directly upon the question of the possible synonymy of the specific designations previously introduced. Although an inspection of the literature immediately reveals the fact that specimens with eyes as large as or larger than in the large-eyed form now on hand have been well known to the earlier investigators, it is, on the other hand, also found that none of the first descriptions of any previously named species except *A. gilli* Bean refer to specimens with their eyes contained less than three times in the postorbital length of the head. In regard to *A. gilli*, Messrs. B. A. Bean and W. Reid of the U. S. National Museum have very kindly verified the original description of the type specimen in regard to the proportion between the eyes and the postorbital part of the head, the diameter of the former being found to be contained $2\frac{1}{2}$ times in the length of the latter. At the writer's request, Dr. Bean has, on the other hand, also supplied the following information concerning the type of *A. gilli*: (1) that its interorbital width is only one-half of the diameter of its eyes, and (2) that the general outlines of the head both in the lateral and dorsal views "seem to be rather even, with no tendency to bulge in the region of the eyes." In the large-eyed specimen now at hand the interorbital width is fully equal to the diameter of the eyes, in spite of the size of the latter, and the orbital region of the head bulges most prominently and conspicuously both in the dorsal and lateral views of the head as shown in the accompanying outline illustrations. From a comparison of the type of *A. gilli* with the original drawings for these figures, Messrs. Bean and Reid have also found that the former more nearly resembles the outlines of the form here identified as *A. infans*, although they observe that the postorbital portion of the head is relatively shorter and the interorbital narrower than in the sketch of the latter.

It is perfectly evident from these considerations that the large-eyed form now

at hand cannot be identified with *A. gilli*, nor can it, as already made out on page 13, be identified with any other previously named species, as the original descriptions of these all refer to specimens with smaller eyes. A new species, *A. exophthalma*, is therefore introduced.

In regard to the taxonomy of the remaining forms pertaining to the genus *Avocettina*, the author is far from being satisfied that the unispecific conception of this genus prevalent in the more recent literature and further elaborated by Roule and Bertin in their monograph (1929, p. 22) has been adequately supported by properly analyzed evidence. We have already seen in the preceding that the material described by Roule and Bertin under the common designation of *A. infans* must probably have comprised at least two quite distinct forms, perhaps corresponding in part to the two separate species in the collections now at hand. It furthermore, seems that neither the measurements of *A. gilli*, on one hand, nor those of *A. bowersi*, on the other, do actually fall within the normal range of variations of one single species with the average proportions and appearance ascribed to *A. infans*. A point upon which particular confusion, perhaps largely due to misprints, seems to exist in the literature is in regard to the observed proportions between eyes and interorbital space. According to Günther (1887, p. 264), the diameter of the eyes is in *A. infans* about twice the width of the interorbital space. Brauer (1906, p. 129) gives: "Auge . . . zur Breite des Interorbitalraums 1: 1.2-2," but in the measurements of one specimen (loc. cit. p. 130) the diameter of the eyes is recorded as 3.5 mm. with an interorbital width of only 3 mm. Weber and Beaufort (1913-22, Vol. III, p. 334) also give the proportion as "eye . . . twice or somewhat less than twice in interorbital space." It is unfortunate that this feature has not received any consideration in Roule and Bertin's monograph. Turning from this confusion of the literature to the material at hand, we find the two specimens of the small-eyed form in perfect agreement with each other, in spite of their great difference in size, their interorbital widths equalling three-fourths (0.76) and four-fifths (0.8), respectively, of the diameter of the eyes. A further study of the individual variations in this feature would undoubtedly be very valuable for our understanding of the genus *Avocettina*. The following key may serve to differentiate the two species herein reported upon according to the three specimens on hand:

1. Eyes moderate, about 3 in the postorbital length of the head. Interorbital space, however, conspicuously narrower than the diameter of the eyes. Outlines of the head rather straight and even, both in the dorsal and in the lateral view, without any bulge in the orbital region.
A. infans (Günther)?
2. Eyes large, only about $2\frac{1}{2}$ in the postorbital length of the head. Interorbital space wide, equal to the diameter of the eyes. Orbital region bulging prominently in the outlines of the head, both in dorsal and in lateral view.....*A. exophthalma* n. sp.

? *Avocettina infans* (Günther 1878)?

1 specimen, No. 2657 B. O. C. Station 39, March 29, 1927. N. 22° 42' 33".
W. 74° 23'. 8000 feet wire.

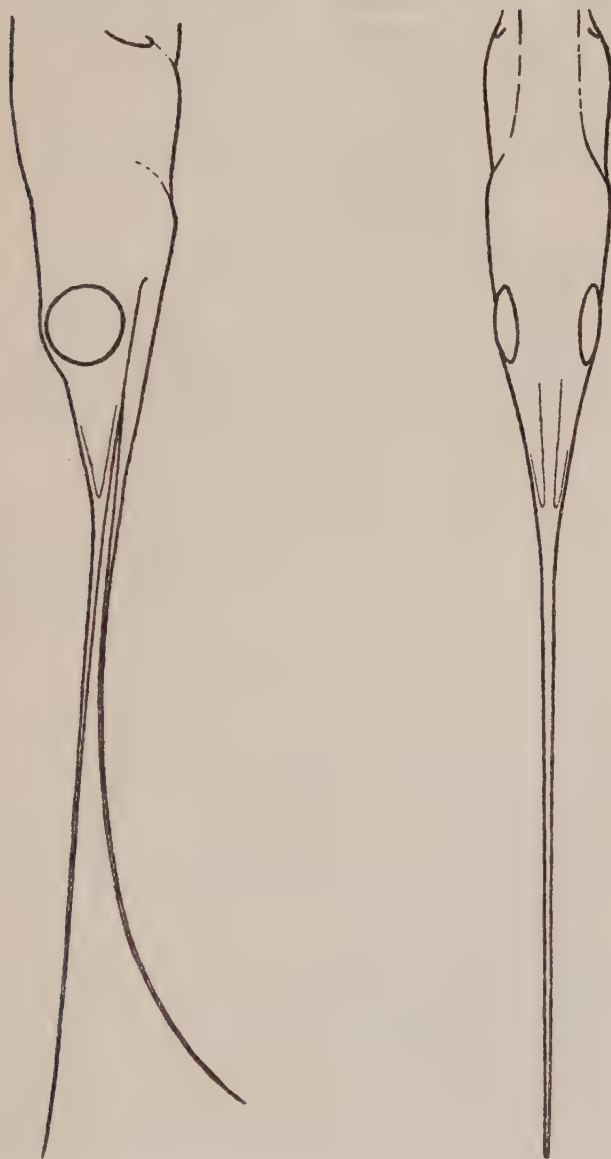


Figure 7. Head of *Avocettina infans* Günther in lateral view (above) and dorsal view (below).

1 specimen, No. 2658 B. O. C. Station 48, April 4, 1927. N. $21^{\circ} 44'$. W. $72^{\circ} 43' 24''$. 7000 feet wire.

Provisionally identified with Günther's species on the strength of the similar proportions between the eyes and the postorbital length of the head, as already made out in the preceding discussion. In the specimens at hand the interorbital width is relatively greater than in Günther's description, equalling three-fourths to four-fifths instead of only one-half of the diameter of the eyes. Whether this difference should be taxonomically significant or not can only be decided by a further study of the type and other collections. Some measurements are given in the table below, together with those of *A. exophthalma*.

***Avocettina exophthalma* n. sp.**

1 specimen, No. 2656 B. O. C. (TYPE.) Station 18, March 10, 1927. N. $23^{\circ} 42' 20''$. W. $76^{\circ} 43' 20''$. 7000 feet wire.

Mainly characterized by its proportions, the large eyes and wide interorbital space, and by the general shape of the head with the prominent bulge of the interorbital region both in the dorsal and lateral views. These features have been sufficiently dealt with in the preceding discussion and figures (p. 17, fig. 8) and in the accompanying table of measurements:

MEASUREMENTS OF *Avocettina* AND *Labichthys*

Species:		<i>Avocettina infans</i>		<i>Avocettina exophthalma</i>	<i>Labichthys carinatus</i> (see p. 18)
Total length in mm.		604	390	620	605
Length of head		9.3 ²	12.3	12.2	15.6
Length of snout	In	6.5 ²	9.5	9.1	11.9
Diameter of eye	per cent	0.68	0.64	0.89	1.16
Interorbital width	of total	0.52	0.51	0.89	0.73
Postorbital length of head	length	2.1	1.8	2.2	2.8
Distance from P ¹ to A		6.7	7.1	7.5	2.8

¹ Measured from the upper anterior end of the pectoral fin base.

² Bill (snout) broken and incomplete.

Although the tips of both jaws are missing, the curvature and finely tapered caliber of the remaining parts rather seem to indicate that the lost portions can probably not have been very large. The lower jaw is much more delicate and strongly curved than the upper, and probably also normally considerably shorter.

There are about 194 pores in the lateral line, about 310 dorsal and about 270 anal fin rays.



Figure 8. Head of *Avocettina exophthalma*, n. sp., in lateral view (above) and dorsal view (below).

The anterior portion of the dorsal fin (about 10 rays) is somewhat elevated, and more erect than the rest of this fin, which is much lower and less developed than the anal. Similar measurements to those made on the genera *Serrivomer* and *Platuronides* (see page 4) show the first 100 rays of the dorsal fin to occupy exactly one-third (33 per cent) of the total length of the fish, or 0.33 per cent of this length per ray. The first two hundred rays cover 63 per cent of the total length, with an average of 0.30 per cent per ray of the second hundred. The bases of the remaining 110 rays cover approximately 24.5 per cent, whereof about 2.8 per cent, or 0.14 per cent per ray, fall upon the last 20 rays, and about 21.7, or 0.24 per cent per ray, upon the preceding 90. While the fin-rays on the whole, of course, show a closer arrangement than in *Serrivomer* or *Platuronides*, in accordance with their greater number, they do, on the other hand, not show a relative concentration of rays at the end of the tail similar even to the slight concentration observed in *Serrivomer*, the maximum variation in the average density of the rays for a group of twenty in *Avocettina exophthalma* being only in the order of magnitude of the ratios 1 : 2 to 1 : 3, instead of about 1 : 9.

Genus **Labichthys** Gill and Ryder

Labichthys carinatus Gill and Ryder 1883

1 specimen, No. 2720 B. O. C. Station 23, March 14, 1927. N. 24° 28' 35".
W. 77° 28' 30". 8000 feet wire.

The accompanying outline drawings of the head of the very perfect specimen now at hand, and the measurements rendered in the table on page 16, may serve

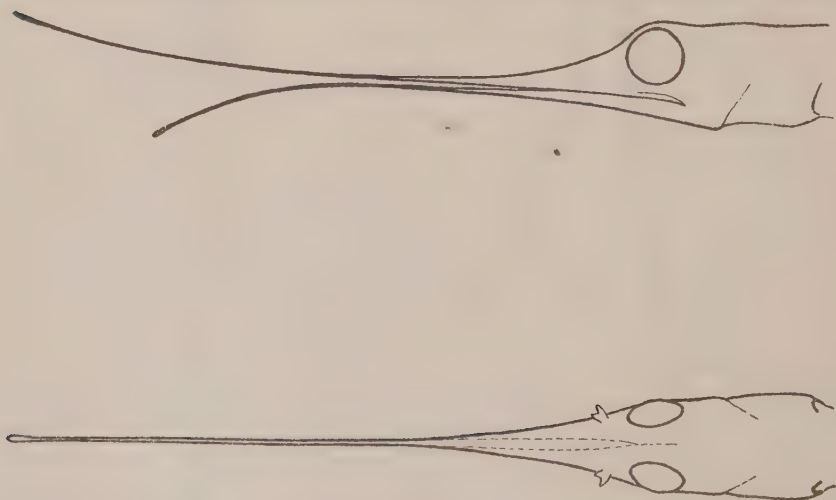


Figure 9. Head of *Labichthys carinatus* Gill and Ryder in lateral view (above) and dorsal view (below).

to amplify the very scanty descriptions of this species previously incorporated in the literature.

In lateral view the head is very similar to that of *Avocettina exophthalma* (see fig. 8), with the orbital region quite prominent in the dorsal profile; while the dorsal aspect, on the other hand, rather resembles that of *A. infans*, the inter-orbital space being relatively narrow in proportion to the large eyes, and the lateral outlines confluent. The rostral ridges, for which the species has been named, are not very conspicuous and prominent in a fresh or an unshrunk formalin specimen, merely appearing as two faint edges surrounding the flat, lanceolate, medio-dorsal surface of the snout, which, in the specimen now at hand, is also conspicuous by a much paler pigmentation than that covering the rest of the head. Only upon shrinkage of the soft parts covering the rostral "groove" of the skeleton do these rostral edges gain the prominence of ridges or crests. Their outlines, or rather the outlines of the rostral groove, are indicated in the figure.

Family NESSORHAMPHIDAE

Genus **Nessorhamphus** Schmidt 1930

Nessorhamphus ingolfianus (Schmidt 1912)¹

Leptocephalus ingolfianus Schmidt 1912,¹ *vide* Schmidt 1930.

Nessorhamphus ingolfianus Schmidt 1930, p. 273, pl. IV-V.

Avocettina scapularostris Borodin 1929, p. 109; 1931, p. 74, pl. 3, fig. 1-3.

1 specimen, No. 2713 B. O. C. Station 58, April 20, 1927. N. 23° 24' 15".

W. 64° 29'. 10,000 feet wire out.

A typical specimen about 125 mm. long.

Family CONGRIDAE

Through gradual accumulation, particularly in the more recent literature, of new species and genera introduced with only partial consideration of the family as a whole, the taxonomic conditions within the Congridae have reached such a state of confusion that it has become extremely difficult to form any clear conception of the known and the unknown, of valid distinctions and mere duplications, particularly in the case of the deepsea forms which have to be considered on a cosmopolitan basis. Faced with these difficulties in the task of identifying or describing as an apparently new species one single deepsea specimen only, the author at first made a strenuous effort to coördinate the literature in a synoptic form, as a basis for the identification or description of the species on hand. This attempt, however, soon had to be abandoned as hopeless and it then became necessary to resort to the "historical approach," eliminating species and genera one by one without a coördinate system for the whole, in order to arrive at the proper systematic position and give justification for the introduction of the new species here discussed.

¹ Vid. Medd. Dansk. Naturhist. Foren. Vol. 64, p. 49, Copenhagen, 1912.

Beginning with Günther's arrangement of the apodal fishes (Günther 1870, p. 19) in which the whole order is designated as one family, the Muraenidae, we find this "family" divided into two "subfamilies" and ten "groups." Among these subdivisions our species would fall within the fourth group of the first subfamily, group "*D. Anguillina*," comprising the genera *Anguilla*, *Conger*, *Congromuraena* and *Uroconger*. This already at once eliminates the genera *Heteroconger*, *Muraenesox*, *Nettastoma*, *Saurenhelys*, *Oxyconger*, *Hoplunnis* and *Neoconger*, all of which are often to be found included in the family Congridae in the subsequent literature dealing with these fishes. Dr. Günther's key (loc. cit. p. 20) further permits us to eliminate *Anguilla*, *Conger* and *Uroconger*, while a perfect agreement is found to exist between the species at hand and the definition of the genus *Congromuraena*. It is also clear, however, that our species cannot be identical with any one of these described by Günther. Taking the Catalogue of Fishes as our starting point, our search thus narrows down to a comparison with the new or emended specific descriptions added to the genus *Congromuraena* and the new genera added to the Congridae after the publication of Günther's work.

Between 1870 and 1898 six new genera referable to the family Congridae (see Jordan 1923, A Classification Of Fishes, p. 131)¹ and a great number of new species of *Congromuraena* were introduced. Of the new genera the following can be eliminated from consideration in regard to the identification of the species on hand by the features mentioned after the name of each genus:

Poecilconger Günther (Proc. Zool. Soc. London, 1871, p. 673), anterior nostril without tube; dorsal fin commencing well in advance of gillopenings; head without muciferous cavities. *Coloconger* Alcock (Ann. Mag. Nat. Hist. 1889, Ser. VI, Vol. 4, p. 456), teeth in a single continuous ridge in each jaw, none on the vomer. *Xenomystax* Gilbert (Proc. U. S. Nat. Mus. Vol. XIV, 1892, p. 348), mouth extending beyond eye (but not far); head subequal to trunk; posterior nostril midway between eye and tip of snout. These features would also seem sufficient to exclude the three genera in question from the group of genera inquirendae further discussed in the following. The genus *Euleptocephalus* Strömman (Leptocephalids in the Univ. Mus. Upsala. Inaug. Dissert. Upsala 1896, p. 5) has reference only to larval forms and need not concern us here until its adult relationships may become established. *Todarus* Grassi and Calandruccio (Atti Ac. Lincei Roma, Vol. V, p. 349, 1896), head and trunk less than one-fifth of the total length.

The diagnosis of *Promyllantor* Alcock (Ann. Mag. Nat. Hist. 1890, Ser. VI, Vol. 6, p. 310) does not seem generically distinct from the definitions of *Con-*

¹ *Scolenchelys* Ogilby (Proc. Lin. Soc. New S. Wales, Vol. XXII, 1897, p. 246) has been erroneously listed by Jordan (1923) among the genera of the Congridae although apparently it is only a synonym of *Muraenichthys* Bleeker of the family *Echelidae* as already previously recognized by the same author (Jordan, 1920, The Genera of Fishes, Pt. IV, p. 477). New genera introduced into the groups combined by Regan (1912) within the Congridae, but often separated by others (see Jordan 1923, p. 131), into two distinct families, the *Nettastomidae*, (tongue adnate etc.), and the *Heterocongridae* (ribbon-like, depth about one-fiftieth to one-hundredth of length), will not be considered here as their differentiation from the type of species with which we are here concerned is obvious without any discussion. This, however, should not be taken as an expression of any definite opinion upon the classification of these forms, although family subdivisions seem reasonable in the present case.

gromuraena current in the literature at that time, and had therefore best been considered in conjunction with the subdivision of the latter genus subsequently attempted by Ogilby (Proc. Linn. Soc. N. South Wales, 1898, Vol. XXIII, pp. 284-294). Since Ogilby in his revision of these forms has given consideration to the descriptions of all new species introduced between 1870 and 1898 inclusive,¹ as well as to those already dealt with in the Catalogue of Fishes, and has shown their arrangement relative to the new generic definitions introduced by him, we may now use these definitions for a further elimination of possibilities by the identification of the species now at hand. Ogilby's generic definitions can be synoptically arranged in the following manner:

- (1). [Teeth granular]. Vent well in advance of the middle of the total length. *Eyes large.*² Head much shorter than the trunk. Dorsal fin beginning behind the bases of the pectorals.....*Congermuraena* (1)
- (2). [Teeth acicular]. *Vent usually but little in advance of the middle of the total length.* Head much shorter than trunk. *Premaxillary patch of teeth not extending conspicuously forward beyond the mandible. Eyes large. Dorsal fin beginning above or nearly above the bases of the pectorals. Cleft of mouth not extending beyond middle of eyes.*.....*Congrellus*³ (2)
- (3). [Teeth acicular]. Premaxillary patch of teeth extending conspicuously forward beyond the mandible. *Head large, subequal to trunk. Cleft of mouth extending behind middle of eye. Eyes small. Dorsal fin beginning above or nearly above the bases of the pectorals. Vent far in advance of the middle of the total length.*.....*Bathycongrus* (3)

In regard to the distinctions made between "granular" and "acicular" teeth, the writer agrees with Barnard (Ann. South African Mus. Vol. XXI, Pt. 1, 1925, p. 189) that the separation on this point would "seem to be impossible in practice," being too much a matter of personal judgment and interpretation of the only vaguely differentiated descriptive terms. This feature has therefore been disregarded in the following discussion. To the definitions of Ogilby's three genera, it will now be practical to add, as number 4, a similar definition of *Promyllantor* Alcock, extracted from the generic diagnosis and specific description of the type. Where the definition of *Promyllantor* agrees with that of either one of the three genera already considered, this agreement will be indicated after each special feature, by bold numerals between parentheses corresponding to the numerals in the above key.

¹ Ogilby's lists of species in the three genera recognized by him (*Congermuraena*, *Congrellus* and *Bathycongrus*) have been checked by the writer against all new entries under the generic headings of *Congromuraena* and *Ophisoma* given in the Zoological Record from 1870 to 1898 inclusive.

² For explanation of italics see the text on page 22.

³ A synonym for *Ariosoma* Swainson (see Jordan: Genera of Fishes, p. 483). Both designations have received considerable usage in the literature, and references must be looked for under each.

- (4). Tail a little over half the total length (2). Eyes rather small (3). Head much shorter than trunk (1 and 2). Dorsal fin beginning behind the bases of the pectorals (1). Cleft of mouth not extending behind the middle of the eyes (2).....*Promyllantor*

It may be seen from the above that the genus *Promyllantor*, as far as the published information goes, differs from Ogilby's three genera only by the combination of its characters but not by a single distinctive feature of its own. The issue becomes further confused by the features of a second species *P. alcocki*, added to the genus *Promyllantor* by Gilbert and Cramer (Proc. U. S. Nat. Mus. Vol. XIX, 1897, p. 405). *P. alcocki* differs from the type of the genus and from Alcock's generic definition¹ by having the head and trunk much shorter than the tail. In this and most other features, so far as described, *P. alcocki* would seem to agree with Ogilby's *Congermuraena* sensu stricto (1), but remains distinct, however, by its very small eyes, in which respect alone it might agree with *Bathyconger* (3).

In the four generic definitions reviewed in the preceding the features by which each "genus" disagrees with the species on hand have been indicated by the use of italics, while the single characters by which this species agrees with any particular one of the four genera is pointed out in the following by the corresponding bold numerals in parenthesis after each feature:

- (5). Premaxillary patch of teeth extending conspicuously forward beyond mandible (3). Head much shorter than trunk (1, 2 and *Promyllantor alcocki*). Eyes very small (3 and *P. alcocki*). Dorsal fin beginning behind the bases of the ventrals (1 and *P. alcocki*). Cleft of mouth scarcely reaching to orbit (2 and *P. alcocki* (1 ?)). Head and trunk much shorter than tail (1, 3 and *P. alcocki*).....*Specimen on hand*

Through this synoptic revision we thus find that neither the specimen on hand nor *Promyllantor alcocki* can be fitted into any one of the four genera reviewed in the preceding, although neither form has any generically distinctive features of its own, merely a recombination of characters already well known from other species. The case represents exactly the same picture as that shown in the relationship of the geno-type and the generic diagnosis of *Promyllantor* to the three genera defined by Ogilby (see above). It thus appears that the various single characters considered in the definitions of *Congromuraena*, sensu stricto (Ogilby), *Congrellus*, *Bathyconger* and *Promyllantor* can occur in almost any combination in the single species, and that generic distinctions based upon their combination can therefore only lead to a very arbitrary, vague and impractical classification. Since, moreover, none of the variations in point of any one character alone, as shown by these definitions, is even nearly significant

¹ Alcock's expression "tail about as long as the trunk" should obviously read "as long as the head and trunk combined," as shown by the specific description of the geno-type.

enough or sufficiently well defined to justify generic differentiations on the basis of distinctions in one single feature only, we are therefore forced to the conclusion that the available information does not permit us to retain the four above-mentioned genera as separate from each other, and they are therefore herewith all provisionally combined into the genus *Ariosoma* Swainson, *sensu lato* (= *Congromuraena* Kaup).

Of the new genera of *Congridae*¹ introduced between 1898 and 1925 the following three are clearly set apart from the group of forms here considered by the features mentioned after the name of each:

Veternio Snyder (Bull. U. S. Fish Commission, Vol. XXII, 1902 (1904), p. 516), no teeth, vomer, maxillaries and mandibles with broad, smooth, hard areas. *Microconger* Fowler (Proc. Acad. Nat. Sci. Philadelphia, Vol. LXIV, 1912, p. 9), subgenus of *Conger*, "teeth largely uniserial." *Rhechias*² Jordan (Proc. U. S. Nat. Mus. Vol. 59, 1922, p. 644), tongue adnate, patch of canines anteriorly in upper jaw, pectorals present.

The same does not, however, hold good of the following two genera introduced during the same period, inasmuch as they do not, so far as the available information goes, seem clearly differentiated from the group here provisionally designated by the generic name of *Ariosoma*, *sensu lato*. The genus *Congrosoma* was introduced by Garman in 1899 (Mem. Mus. Comp. Zoology Harvard Coll.

¹ The generic designation *Atopichthys* Garman (Mem. Mus. Comp. Zool. Harvard, Vol. XXIV, 1899, p. 327) was merely introduced as a substitute term for *Leptocephalus* to be applied to the leptocephalid larvae not belonging to the genus *Conger* (*Leptocephalus*), and does not require any further consideration here.

Metopomycter Gilbert (Bull. U. S. Fish. Comm., Vol. XXIII, 1903 (1905), p. 585) is listed by Jordan, 1923 (Classification of Fishes, p. 131) among the *Congridae*, but should evidently have been placed among the *Nettastomidae*, as done by Gilbert himself, if these two families are to be kept separate. *Metopomycter* is described as having no pectorals and no (free) tongue.

The position of the genus *Mayerina* Silvester (Carnegie Inst. Yearbook, Vol. 14, p. 214. Washington, 1915) is not very clear. In the original description it is referred to the *Muraenesocidae*, but the features upon which this classification is based are not discussed in the text. The genus is under any circumstance very far removed from the group of genera here considered and need not concern us in this report.

Endeconger was introduced by Jordan 1923 (Classification of Fishes, p. 131) as a new name for *Brachyconger* Norman* (Ann. Mag. Nat. Hist. Ser. 9, Vol. 10, 1922, p. 217) and erroneously referred to the *Congridae*, although Regan had shown the genus to belong with the *Xenococongridae*.

² First placed with the *Muraenesocidae*, *sensu lato*. With the more restricted interpretation of this family adopted in Jordan's "Classification of Fishes," in accordance with the work of Regan (Ann. Mag. Nat. Hist. Ser. VIII, Vol. 10, 1912, p. 385), *Rhechias* has been transferred to the *Congridae* as conceived by Jordan. The present writer is greatly inclined to question whether the broadness of this conception of the *Congridae* is consistent with the refinement of the other subdivisions (families) of the congroid eels recognized in Jordan's classification.

* In Jordan's Classification of Fishes the genus *Brachyconger* has been erroneously credited to Regan, instead of Norman.

Vol. XXIV, p. 308) with the comment that "this is a *Congermuraena* with the head from the eyes forward more shortened, with the upper bands of teeth more closely joined anteriorly, with the dorsal originating farther backward [between the bases and the tips of the pectorals.—*auth.*], and with the vent farther forward of the midlength [snout to vent three-eighths (37.5 per cent) of total.—*auth.*]." In regard to the origin of dorsal fin and the position of the vent the genus *Congrosoma* thus falls well within the range of intergrading variations already observed within *Ariosoma*, *sensu lato*. The various other features especially emphasized by Garman are obviously too vaguely descriptive and incapable of accurate definition in objective terms to form a practical and reliable basis for generic distinctions. *Congrosoma* is therefore also included within the group here combined under the designation of *Ariosoma*, *sensu lato*. What has just been said about the genus *Congrosoma* also applies to *Pseudophichthys* Roule (Compte Rend. Acad. Sci. Paris, Vol. 160, 1915, p. 283; Bull. Inst. Oceanogr. Monaco, No. 320, 1916, p. 4; Res. Comp. Sci. Monaco, Fasc. LII, 1919, p. 96), the type species of which would seem to be very closely related to the type of *Congrosoma*, as far as can be judged from descriptions and figures, although there can be no doubt about the specific distinction between the two genotypes.

In an analysis of the Japanese Congridae, Jordan and Hubbs (Mem. Carnegie Mus. Vol. X, No. 2, p. 191 and following, Pittsburgh 1925) endeavor to introduce a new system for the classification of this family of eels, with distinctions mainly based upon the characters and the arrangement of the teeth. Their effort suffers from the fact that it is not based upon a systematically complete consideration of the family as a whole, but merely upon a geographically circumscribed study of its representatives in Japanese waters. Several important groups, most notably the one with which we are here particularly concerned, are therefore left largely or entirely unaccounted for in the analysis of the genera rendered by these authors, and the system evolved for the Japanese forms has consequently not as yet received the crucial test of a universal application to the entire family, nor does it seem probable to the present writer that it would be able to stand such a test, although it undoubtedly embodies a great improvement over previous methods. The greatest difficulty by a universal application of the system of Jordan and Hubbs would probably be met with already at the main (first) subdivision to which these authors subject their Japanese forms in their key to the genera, namely according to whether the premaxillary teeth are 1) "entirely within the closed mouth (rarely slightly exposed in *Anago*)" or 2) "largely or entirely in front of the mouth on the lower surface of the projecting snout." While the extent to which the premaxillary dentition is contained within, or projects beyond, the boundary of the mouth proper may be useful for the differentiation of single species or smaller systematic groups, when the differences are sharp and conspicuous, it is, in the present

writer's opinion and experience, an entirely impracticable distinction for the separation of major subdivisions of the family. The difficulties on this point arise from three sources: 1) the apparent existence of actual intergradations in nature;¹ 2) the difficulty of formulating any sharp and objective definitions;²

¹ *Vide* the much more cautious terms applied by Ogilby to the description of this feature in his definition of the genus *Congrellus* (see page 21): "Premaxillary patch of teeth not extending conspicuously forward beyond the mandible." See also Jordan and Hubb's own reservations for the genus *Anago*.

² The following considerations may serve to illustrate these practical difficulties. In many of the eels here considered neither the upper nor the lower teeth form any sharp and well defined cutting edge by which the boundaries of the mouth are clearly defined, the dentition, on the contrary, generally forming a rounded edge over each jaw, often of very slight curvature. A fairly typical case is shown in the accompanying diagrammatic illustration. In such a case the expression: "within the closed mouth" should in its strictest sense mean within the line along which the upper and lower jaws meet (at vertical A in figure 10). But this line can obviously not be seen

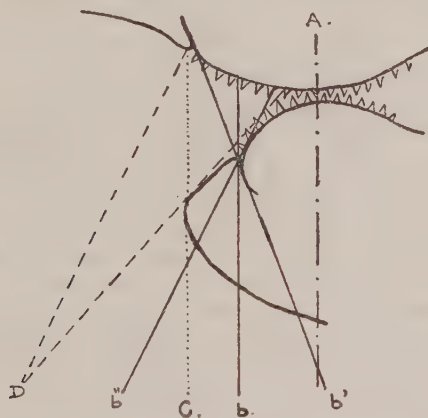


Figure 10. Diagrammatic median section through the jaws of a congroid eel.
Explanations in text.

when the jaws are actually closed and cannot be determined when they are open. This definition can therefore clearly not be applied to the practical identification of the species. "Within the closed mouth" would, on the other hand, if not more sharply defined, undoubtedly also often be given a looser interpretation in accordance with whether the premaxillary teeth are hidden by the lower jaw in ventral view or not; a relationship which has received a more exact expression in Ogilby's consideration of the extent to which the premaxillary dentition does, or does not, project forward of the mandible. The datum line for this comparison would be the vertical *b*. The practical application of this comparison is, however, obstructed by the following difficulties: 1) that even a relatively very slight angular deviation from the

3) the difficulty of applying in an objective manner such definitions, if formulated, to the actual observation of the specimens except in the most clearly defined cases. Since the minor supporting characters used by Jordan and Hubbs in their diagnosis of the two main subdivisions of the Japanese genera are hardly differential at all, it therefore seems indicated that another synoptic arrangement according to other combinations of generic characters will have to be developed for a universal classification of the family as a whole. This, however, is patently beyond the scope of the present report, for which only one single species is at hand. Since all the new genera introduced by Jordan and Hubbs are based upon old species, most of these have already been eliminated from consideration by the identification of the species at hand through the preceding analysis of the earlier literature. It may be worth pointing out, however, that if we try to run our species down according to the key to the Japanese genera, we find that it occupies an intermediate position between the two genera *Rhynchocymba* Jordan & Hubbs and *Rhynchoconger*, agreeing with the former in the shape of the posterior nostril, which is a narrow slit, with entire rim, and with the latter genus in having the premaxillary patch of teeth in full contact with the vomerine patch, the anterior ends of the maxillary bands thus being widely separated; in the presence of a pair of enlarged pores between the anterior nostrils;¹ and in the presence

true vertical b , which is very hard to determine accurately, will make a great difference in the results of the comparison, as shown by the oblique lines b' and b'' in fig. 10; and 2) that the lower lip has to be pressed backward without altering the curvature of the lower jaw itself to permit the observations to be made, which is not always very easy to do, particularly not in small preserved specimens of a small-mouthed form. Comparison by vertical b must, therefore, on the whole, also be regarded as impracticable except where a limited number of forms with great specific differences are concerned. Comparison by the extent to which the dentition might project beyond the lower lip (vertical c) would be relatively simple in itself, but is rendered quite unreliable by the degree to which this relationship would be influenced by the state of preservation of the single specimens. That the natural view of the upper dentition in the undisturbed specimen (from point D in the figure) cannot form a consistent basis for comparison is obvious without further discussion. Although it is perfectly true that the premaxillary dentition may in many forms be largely or even entirely in front of the mouth, thus leaving absolutely no doubt on this point, the present writer therefore, nevertheless, does not believe that it is practicable, on account of the great number of questionable cases, to make this feature a primary basis for the differentiation of genera or groups of genera. It seems probable, however, that the feature may be of a considerable value as a secondary diagnostic character for those genera in which it may prove to be constant and always well defined.

¹ It is assumed that the expression "a pair of enlarged pores between the nostrils" has reference to the anterior nostrils of the two sides and not to the anterior and posterior nostrils of the same side, although the syntactic position of the expression in the context would rather call for the latter interpretation, in which case our species would agree with *Rhynchocymba* and not with *Rhynchoconger*. It is unfortunate that

of a fleshy keel occupying the antero-ventral line of the snout although it does not end posteriorly in a small free process as in *Rhynchoconger*. Our species is entirely intermediate in regard to the relative dimensions of the premaxillary and vomerine patches of teeth, the former being somewhat, but not much, smaller than the latter. This state of affairs, while clearly differentiating the species on hand from any of those considered by Jordan and Hubbs, also throws considerable doubt upon the general validity of the distinctions made between the two genera *Rhynchocymba* and *Rhynchoconger*. Whether it is possible to make any sharp and general distinction of generic significance on the basis of the prominence of the snout alone also seems very questionable, or rather improbable judging from the accounts of species other than those in the Japanese waters. *Alloconger* Jordan and Hubbs must therefore also be included together with *Rhynchocymba* and *Rhynchoconger* in the list of genera *inquirenda* related to the genus *Ariosoma* accumulating from this study of the literature. It furthermore seems very improbable to the writer that a really valid distinction from the latter genus can be based upon the claim that *Alloconger* "at least differs in having the premaxillary teeth largely exposed,"¹ since intergrading degrees of exposure seem to occur also in *Ariosoma*.

The genus *Hildebrandia* was introduced by Jordan and Evermann (Proc. California Ac. Sci. Ser. IV, Vol. 16, No. 15, 1927, p. 502) for *Congermuraena flava* Goode and Bean with the claim that it should be "well distinguished from *Ariosoma* and *Anago* by the long snout, the projecting lower jaw, the very long tail, and the anterior insertion of the dorsal,—far in advance of the gill-opening." Of these various characters, however, only the anterior insertion of the dorsal fin would seem to be truly distinctive of *Hildebrandia*, as compared with the other proposed genera here considered, and this feature alone is hardly enough to exclude *Hildebrandia* from the group of genera *inquirendae* here provisionally synonymized with *Ariosoma*, *sensu lato*. In regard to the statement about the projecting lower jaw it is rather surprising to have this error appear again in a generic definition by Jordan and Evermann in 1927, after these same authors already, in 1889, in a correction to their Fishes of North America (Bull. U. S. Nat. Mus. No. 47, Pt. III, p. 2801. Washington 1898), have pointed out that the statement in question is solely due to a slip in the original description. The actual fact that the premaxillary dentition projects beyond the lower jaw does, of course, not distinguish *Hildebrandia* from *Bathycongrus* and several other previously proposed genera.

Jordan and Hubbs are not more explicit on this point, since the original account of the genotype of *Rhynchoconger* (*Leptocephalus ectenurus* Jordan and Richardson, Mem. Carnegie Mus., Vol. IV, p. 171, Pittsburgh 1909) gives no reference to the presence of enlarged pores between the nostrils.

¹ Note the cautious inexactness of this definition. See footnote on page 25.

The genus *Pseudoxenomystax*¹ Breder (Bull. Bingham Oceanogr. Coll. Vol. I, Art. 1, p. 6, 1927) again confirms the impossibility of subdividing the complex group of forms centering around the genus *Ariosoma* by any previously proposed method. With reference to Ogilby's classification (see p. 21) *Pseudoxenomystax* agrees with *Congermuraena*, *sensu stricto*, and *Congrellus* in having comparatively large eyes; it differs from *Congrellus* and agrees with *Congermuraena* and *Bathycongrus* in having the vent far in advance of the middle of the body, it agrees with *Congermuraena* and differs from the other two genera in having the origin of dorsal fin well behind the bases of the pectorals; and it finally agrees with *Bathycongrus* and differs from the other two genera by its large head and by the fact that its premaxillary dentition extends very conspicuously beyond the mouth when closed. *Pseudoxenomystax* thus occupies a similar position as *Promyllantor*, showing an even mixture of the features of all of the three genera proposed by Ogilby, although the mixture of characters is far from being the same in the two, *Pseudoxenomystax* and *Promyllantor* agreeing with or differing from each other in exactly the same manner as they agree with and differ from each of the other proposed genera. In Jordan and Hubbs' classification, *Pseudoxenomystax* agrees with the genus *Rhynchoconger* but for the fact that the rim of the posterior nostril is entire and the fleshy keel on the ventral surface of the snout does not end in a free process. *Pseudoxenomystax* therefore also clearly belongs among the genera *inquirenda* here provisionally synonymized with the genus *Ariosoma*, *sensu lato*. The following brief diagnosis may help determining the more exact position of *Pseudoxenomystax* among the other proposed genera of this group:

Genus *Pseudoxenomystax* Breder. HEAD LARGE, SUBEQUAL TO TRUNK. VENT FAR IN ADVANCE OF THE MIDDLE OF THE TOTAL LENGTH. EYES LARGE. DORSAL ORIGIN BEHIND THE BASES OF THE PECTORALS. PREMAXILLARY PATCH OF TEETH LARGELY OUTSIDE OF MOUTH WHEN CLOSED. SNOUT PROJECTING MODERATELY, BUT CONSPICUOUSLY, BEYOND PREMAXILLARIES, ITS VENTRAL SURFACE WITH A SLIGHT FLESHY KEEL ENDING POSTERIORLY WITHOUT ANY FREE PROCESS. TWO ENLARGED PORES BETWEEN THE ANTERIOR NOSTRILS. POSTERIOR NOSTRILS ROUNDED, WIDE OPEN, BUT WITH AN ENTIRE RIM. ANTERIOR NOSTRILS SIMPLE, TUBULAR, SITUATED ON THE VENTRAL SURFACE OF THE SNOUT CLOSE TO THE EDGE. PREMAXILLARY PATCH OF TEETH LARGER THAN VOMERINE PATCH, THE TWO PATCHES BEING IN SOMEWHAT CONSTRICTED CONTACT WITH EACH OTHER, THUS SEPARATING THE MAXILLARY BANDS OF THE TWO SIDES. MAXILLARIES WITH ABOUT SIX SOMEWHAT IRREGULARLY ALTERNATING ROWS OF SMALL

¹ Erroneously referred to the family *Muraenesocidae* in the original description. Although *Pseudoxenomystax* does not possess transverse processes on the caudal vertebrae, it is, with regard to every other character (maxillaries articulating near the end of the snout, tongue almost entirely free) and in its general appearance, a typical representative of the group of the family *Congridae* here considered.

CONICAL TEETH, DECREASING IN SIZE FROM THE EDGE OF THE JAW INWARDS. VOMER WITH SOME MOLAR-LIKE TEETH AND SOME SMALLER, CONICAL ONES, VERY IRREGULARLY SCATTERED. NO ENLARGED FANGS IN ANY PART OF THE MOUTH. TONGUE ENTIRELY FREE ANTERIORLY AND ON THE SIDES. MAXILLARY ARTICULATED WITH ETHMOID AT THE END OF THE SNOUT. CAUDAL VERTEBRAE WITHOUT TRANSVERSE PROCESSES.

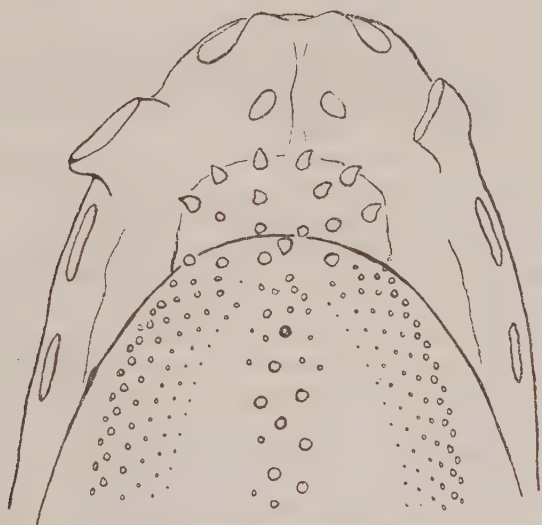


Figure 11. Ventral view of snout and upper dentition in *Pseudoxenomystax dubius* Breder, with outline of lower jaw.

The genus *Grammatocephalus* Norman (Discovery Rep. Vol. II, Oceanic Fishes and Flatfishes, p. 338. Cambridge 1930) seems sufficiently distinct from the group here considered not to require any further discussion here, the distinguishing features being: tail shorter than trunk, vomerine dentition in a horseshoe-shaped patch, head with fine ridges, etc.

The various new species introduced since 1898 under generic designations which might indicate the possibility of a relationship with the specimen at hand (*Congromuraena*, *Congrellus*, *Bathycongrus*, *Promyllantor*, *Ophisoma*, *Ariosoma*, *Congrosoma*, *Pseudophichthyus* and *Pseudoxenomystax*)¹ can all be eliminated from consideration by the special features in their descriptions mentioned after the name of each one in the following list:

¹ Larval forms described under the taxonomic designations of *Leptocephalus* or *Atopichthys* can, of course, not be considered in this connection until their adult identity has been established.

Congrosoma evermanni Garman (Mem. Mus. Comp. Zool. Harvard Coll. Vol. XXIV, p. 308, plate LXII, fig. 1, Cambridge, Mass. 1899): snout less than one-fifth of head. D. 324. A. 265. *Congermuraena caudalis* Garman (ibidem, p. 305): head one-fifth of total length; eyes large, two-thirds of snout. *Congrellus bowersi* Jenkins (Bull. U. S. Fish Comm., Vol. XXII, 1902, p. 422, fig. 1, Washington 1904): eyes large, only $1\frac{1}{2}$ in the snout, which is not prominent (species probably not really belonging to the group here considered). *Congermuraena howensis* McCulloch and Waite (Trans. Proc. Roy. Soc. S. Australia, Vol. 40, p. 438, Adelaide, S. A. 1916): head 1.5–1.6 in trunk; head and trunk only 1.2–1.4 in tail; eyes only 4.9–5.7 in head. *Congrellus meeki* Jordan and Snyder (Proc. U. S. Nat. Mus. Vol. XXIII, p. 347, Washington, 1901): vent in middle of length; eyes 5 in head. *Congrellus roosendaali* Weber and Beaufort (Fishes Indo-Australian Archipelago, Vol. III, p. 261, fig. 112, Leyden, 1916): eye half-length of snout, 5.8 in head; premaxillary patch of teeth separated from vomerine patch. *Pseudophichthys latedorsalis* Roule (Res. Camp. Scient. Monaco, Fascicule LIII, p. 97, pl. VI, figs. 4–4c. Monaco 1919): only 109 vertebrae; eye less than twice in snout, about 6 in head. *Congermuraena albescens* Barnard (Ann. South African Mus. Vol. XIII, pt. 8, p. 442, 1923) and *Congermuraena australis* Barnard (ibidem): eyes large, $4\frac{1}{2}$ to $5\frac{1}{2}$ in head, 1 to $1\frac{1}{2}$ in snout. *Congromuraena guppyi* Norman (Ann. Mag. Nat. Hist. Ser. IX, Vol. 15, p. 313. London 1925): gape extending to below posterior border of eye; origin of dorsal immediately above gill-opening. *Pseudozenomystax dubius* Breder (Bull. Bingham Oceanogr. Coll. Vol. I, Art. 1, p. 6, 1927): eye large (5.3 in head); snout short (4.4 in head); premaxillary dentition largely outside of the mouth when closed.

The fact that this laborious analysis of the literature relating to the group of poorly differentiated genera and species of Conger eels typified by the genus *Ariosoma*, *sensu lato*, had to be undertaken simply as a necessary preliminary step for the identification of one single specimen, probably gives sufficient evidence of the deplorable state of affairs in the taxonomy of these forms. A full account of this analysis is rendered in the hope that it might contribute to the ultimate clarification of conditions by outlining and delimiting the problems involved and thereby perhaps drawing the attention of those, to whom the crucial collections are available, towards the solution of these problems. In the lists of genera and species discussed in the preceding all entries of new descriptions¹ and generic definitions in the Zoological Records for 1898–1929, inclusive, have been considered, except when the forms in question would quite obviously not be referable to the family Congridae in a modern, and more restricted, sense.

Through this study of the previous literature, we have found that the following list of *genera inquirenda* have not been sufficiently clearly and universally differentiated from each other by their given definitions, and by the application of these definitions to a comprehensive cosmopolitan classification of the species, to give any clear evidence of their actual distinctness or to provide a practical means of referring any given species, except the "most typical ones," unequivocally to one genus or another. While it seems quite probable that several genera should be recognized, the existing literature does not permit of their differentiation, and it seems equally certain that the number of generic designations must be greatly reduced by synonymization.

Genus *Ariosoma* Swainson, 1838, *sensu lato*

Provisional synonymy (Synonyms and *Genera inquirenda*)

Ophisoma Swainson 1839, Nat. Hist. Fish., Vol. II, p. 195.

¹ Larval forms of unknown adult identity described under various designations such as *Leptocephalus*, *Atopichthys* etc., have not been included in these considerations.

- Congermuraena* Kaup 1856, Ubers. d. Aale, Arch. f. Naturges., Vol. 22, pt. 1, p. 71.
- Gnathophis* Kaup 1860, Abhandl. Naturhist, Verein Hamburg, 1859, Vol. IV, Abt. 2, p. 7.
- Promyllantor* Alcock 1890, Ann. Mag. Nat. Hist., Ser. VI, Vol. 6, p. 310.
- Bathycongrus* Ogilby 1898, Proc. Linn. Soc. N. S. Wales, 1898, Vol. XXIII, p. 292.
- Congrellus* Ogilby 1898, *ibidem*, p. 286.
- Congermuraena*, sensu stricto, Ogilby 1898, *ibidem*, p. 284.
- Congrosoma* Garman 1899, Mem. Mus. Comp. Zool. Harvard, Vol. XXIV, p. 308.
- Pseudophichthys* Roule 1915, Compt. Rend. Ac. Sci. Paris, Vol. 160, p. 283.
- Alloconger* Jordan and Hubbs 1925, Mem. Carnegie Mus., Vol. X, No. 2, pp. 192 and 195.
- Rhynchocymba* Jordan and Hubbs 1925, *ibidem*, pp. 192 and 195.
- Rhynchoconger* Jordan and Hubbs 1925, *ibidem*, pp. 192 and 196.
- Hildebrandia* Jordan and Evermann 1927, Proc. Calif. Ac. Sci., Ser. VI, Vol. 16, No. 15, p. 502.
- Pseudoxenomystax* Breder 1927, Bull. Bingham Oceanogr. Coll., Vol. I, Art. 1, p. 6. (See page 28).

***Ariosoma perturbator* n. sp.**

1 specimen, No. 2738 B. O. C. Station 20, March 11, 1927. N. 23° 54' 20". W. 77° 09'. 8000 feet wire. 710-720 fathoms depth.

By the process of elimination accounted for in detail on the preceding pages all possible species except *Promyllantor alcocki* Gilbert and Cramer (Proc. U. S. Nat. Mus. Vol. XIX, 1897, p. 405, pl. XXXVI, fig. 1) have been excluded from consideration by the identification of the above recorded specimen. Since the latter did not seem distinct from the former by any external character per-

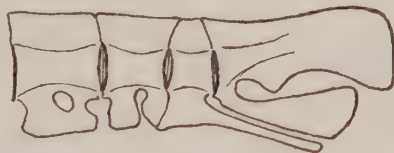


Figure 12. Last caudal vertebrae in *Promyllantor alcocki* Gilbert and Cramer.

mission was obtained from the United States National Museum to have one of the cotypes of *Promyllantor alcocki* stained and cleared for a count of the vertebrae and a very clear X-ray photograph of the specimen on hand was made for the same purpose. From this material it was possible to determine the existence of a difference of 10 between the total number of vertebrae of the Pacific *alcocki* and of the Atlantic specimen now at hand, which is therefore

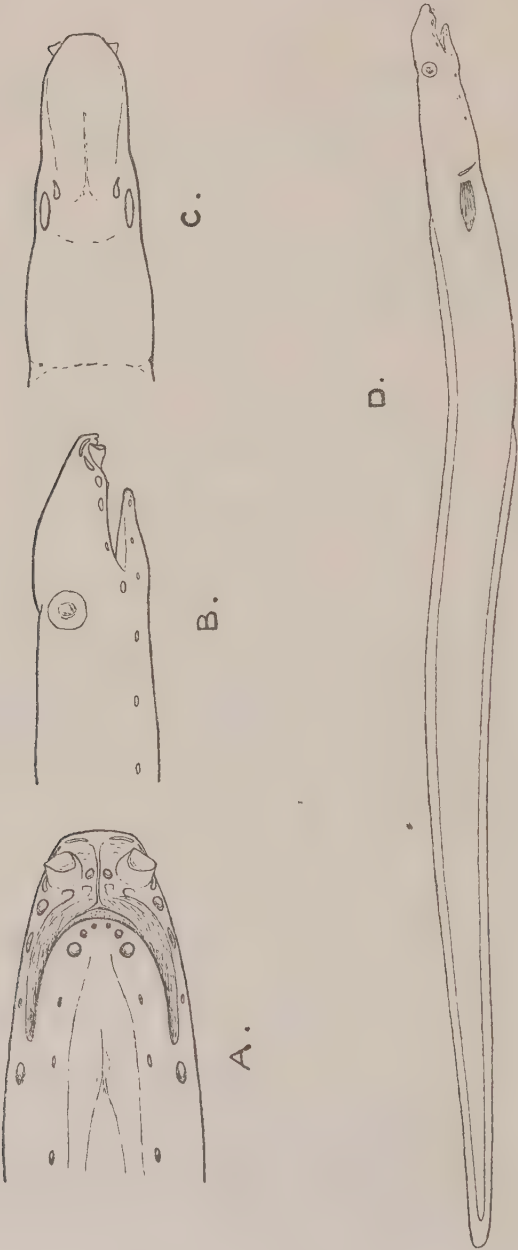


Figure 13. (A) Ventral, (B) lateral, and (C) dorsal view of the anterior part of the head in *Ariosoma perturbator* n. sp.
(D) Total view of type specimen.

described as the type of a new species. In *A. (Promyllantor) alcocki* (cotype) 169 vertebrae, including the ultimate caudal centrum (fig. 12), has been counted, while the total number in *A. perturbator* is only 159.

The general appearance of the species may be seen from figure 13. Head only little shorter than trunk. Snout soft and tumid, broad and very prominent, of a somewhat proboscis-like appearance. Eyes small, far apart, near the dorsal profile, their diameter about one-tenth of the length of the head and about $3\frac{1}{2}$ in snout (soft parts included). Gape short, not reaching to the vertical from the anterior margin of the orbit. Tongue free. Vent at the beginning of the second third of the total length, caudal fin included. Head and trunk sub-cylindrical, tail compressed, gradually tapering. The following measurements have been made:

Total length exclusive of the caudal fin rays, 243 mm. Proportions in per cent of this measurement: Length of head, soft snout included 14.5 per cent. Length of snout, hard parts and skin, only,¹ 3.7. Length of snout, soft parts included, 4.7. Length of gape 3.2. Length of lower jaw 4.0. Diameter of eye 1.4. External interorbital width 2.3. Depth of head 3.4. Greatest depth of body 4.7. Vertical width of gill-opening 2.0. Snout (soft parts included) to dorsal fin 18.1. Snout (soft parts included) to anal fin 35.9. Length of pectorals 3.8. Length of caudal fin rays 2.6.

In all of these proportions and in its general appearance, *A. perturbator* is in excellent agreement with *A. alcocki*.

D. about 230. A. 190–200. 159 vertebrae. Lateral line with 35 pores from its beginning to the origin of anal fin. 110 pores can be counted in all, whereafter the line becomes indistinct.

Teeth small, numerous, in broad bands in upper and lower jaw, and in a wide, continuous premaxillary-vomerine patch (see figure 14). Roof of mouth with longitudinal folds, the outer ones each supporting a series of minute black points of undetermined character. The anterior rim of the upper dentition remains visible from below when the mouth is closed, while the greatest part of the dentition comes within the gape. Judging from the stained and cleared cotype it would appear that the upper dentition in *A. alcocki* is exposed to a much greater extent, practically the entire premaxillary portion of the premaxillary-vomerine patch of teeth and nearly the full width of the maxillary band at its most anterior end remaining outside of the lower jaw when the mouth is closed. A similar relationship between the upper and lower jaws and their dentition is also indicated in Gilbert and Cramer's illustration of the type specimen, and it seems possible that this feature might also be used for distinction between *A. alcocki* and *A. perturbator*.

¹ Measured by pressing one point of the dividers against the end of the snout until stopped against the hard parts. Useful for comparison with shrunken or damaged specimens.

Each anterior nostril is surrounded by three long slit-like pores, one situated transversely across the lower surface of the snout (one on each side of the median. See figure 13 A), and two longitudinally along the latero-ventral edge of the snout in a curve above the base of the nostril. A fourth, wide open pore of ovoid outline is found immediately behind and lateral to each nostril, and is followed at a short distance by a fifth, broadly triangular pore above the anterior part of the upper lip. A sixth narrowly elliptic pore is situated above the posterior part of the mouth and the (maxillary) series ends with a large, wide-open elliptic pore a short distance behind the corner of the mouth. Below the lower jaw three wide-open circular pores situated close together near the symphysis form a short series on each side, rapidly diverging from the median.

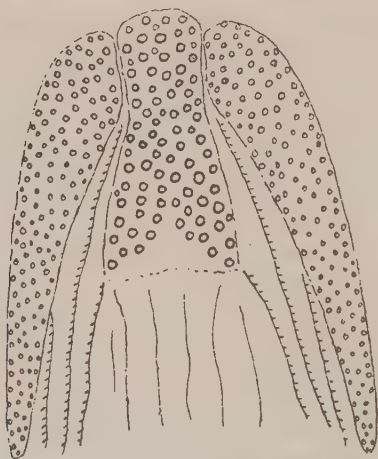


Figure 14. Upper dentition in *Artosoma perturbator* n. sp.

The first of these pores is very small, the second somewhat larger and the third very large. The ventral series is continued posteriorly by four¹ narrowly elliptic, quite small pores on each side, increasing somewhat in size towards the tail and arranged in a line more nearly parallel with the median. The first of these pores is approximately opposite the sixth in the maxillary series, the second immediately in advance of the last maxillary pore, and the fourth at a point corresponding to the posterior end of the hyoid arch, the third pore being about midway between the second and the fourth. There is also a pair of pores of moderate size ("enlarged") between the anterior nostrils, one on each side close to the subrostral keel. There are no other pores than these on the cheeks or any other part of the head.

Anterior nostrils wide, short, tubular, directed obliquely forward from the ventral surface of the snout. Posterior nostrils simple, with entire rims, nar-

¹ Only the first three shown in figure 13 A.

rowly almond shaped, situated with their midpoint approximately in the vertical from the anterior margin of the orbit, on the dorsal surface of the head (figure 13 C).

The upper lip, or labial area, consists of a broad band of dark, finely folded, or wrinkled skin surrounding the upper dentition. A small, dark, fleshy keel arises in the median from the *inner* converging folds of the labial area, dividing the rest of the labial area in the middle and continuing forward between the nostrils and subrostral pores to below the anterior end of the snout. Immediately behind each anterior nostril is a small, open, horseshoe-shaped pit, formed by the branching off and bending back of the outer labial fold at this point. More anteriorly and mesially, behind each subrostral pore, we find a very small, dark, transverse fleshy flap, vaguely connected with the labial wrinkles. In the triangular area between the anterior nostril and the subrostral keel, anterior to the subrostral pore, a few minute, dusky, transverse thickenings of the skin are faintly indicated.

General color light brown, lips and gill-openings much darker.

Family ILYOPHIDAE

Genus *Ilyophis* Gilbert

Ilyophis brunneus Gilbert

Ilyophis brunneus Gilbert, Proc. U. S. Nat. Mus., Vol. XIV, 1891, p. 351, Washington 1892. Jordan and Davis. Rep. U. S. Fish Comm. 1888, p. 670, Washington 1892. Goode and Bean, Ocean. Ichthyol., Special Bull. U. S. Nat. Mus., 1895, p. 141, fig. 162. Jordan and Evermann, Fishes N. and Middle America. Bull. U. S. Nat. Mus. No. 47, Pt. 1, p. 350, Washington 1896. Regan, Ann. Mag. Nat. Hist. Ser. VIII, Vol. 10, p. 387. 1912.

?*Ilyophis brunneus* Barnard, Mar. Fish. S. Africa., Ann. S. Afr. Mus. Vol. XXI, Pt. 1, p. 182, 1925.

Nec *Ilyophis brunneus* Lea, Rep. Sci. Res. "Michael Sars" North Atl. Deep-sea Exp. 1910. Vol. III, pt. 1, p. 18. Bergen 1912 (fide Koefoed 1927).

?Nec *Ilyophis brunneus* Koefoed, Rep. Sci. Res. "Michael Sars." N. Atl. Deepsea Exp. 1910. Vol. IV, Pt. 1, p. 61. Bergen 1927.

Nec *Ilyophis brunneus* Fish, Zoologica, Sci. Contr. New York Zool. Soc. Vol. VIII, No. 5, p. 307.

1 specimen, No. 2737 B. O. C. Station 20, March 11, 1927. N. 23° 54' 20". W. 77° 09'. 8000 feet wire. 710-720 fathoms depth.

Since an X-ray photograph of the above specimen revealed a very considerable discrepancy with the vertebrae counts previously recorded from specimens other than the type of the species, a similar picture of the latter was requested and obtained through the courtesy of the United States National Museum. While the X-ray of the type is not so clear as that of the specimen at hand, it is fortunately clear enough to allow us to count the anterior 132 vertebrae, occupy-

Length without caudal fin in mm.		B.O.C.	Type ¹	Koefoed
		575	362	118
Length of head (to P.)		10.4	11.3	11.0
Length of snout		3.1	3.6	5.1
Length of gape		5.0	5.5	6.8
Length of lower jaw		6.0		
Diameter of eye	In	1.05	1.4	1.7
Interorbital width (inc. soft parts)	per cent	1.8	1.4	
Greatest width of skull	of length	2.5	2.1	
Greatest depth of head	without	3.0	3.6	
Depth of head and lower jaw at anterior margin of orbit	caudal fin rays	2.1	1.9	
Snout to D		11.5	12.1	14.0
Snout to A		31.6	31.7	30.0
Length of P		1.4	1.9	3.0
Depth of body at origin of A		4.0	4.4	

¹ The author is indebted to Mr. B. A. Bean of the U. S. National Museum for kindly supplying the measurements and counts of the type of *Ilyophis brunneus*, except the vertebral count made by the author from X-ray photograph.



Figure 15. Anterior upper dentition (above) and lower dentition (below) in the type of *Ilyophis brunneus* Gilbert, according to wax impressions furnished by the United States National Museum.

ing (with the head) about 93.3 per cent of the total length of the specimen, thus leaving only the posterior 6.7 per cent of the length unaccounted for. In the specimen on hand the anterior 93.3 per cent of the total length contains $128\frac{1}{2}$ vertebrae, $18\frac{1}{2}$ being counted in the posterior 6.7 per cent. The figures for the two specimens are thus in sufficiently close agreement not to give any reason for questioning their taxonomic identity on the basis of this feature, at least, and since no other distinguishing difference could be found, the author feels confident that the two are truly identical. If, on the basis of this conclusion, we are justified in assuming that the extreme caudal portion of the vertebral column must contain approximately the same number of vertebrae in both specimens (18-19), we arrive at a total vertebral count of about 150-151 in the type, and 147 in the specimen now on hand.

Looking through the literature, however, we find the vertebral count of *Ilyophis brunneus* recorded by Lea (*vide* Koefoed, 1927, p. 61) as 132 and by Fish (1927, p. 307) as 127-132. In the case of Fish's records, at least,¹ it is indicated that the counts have been obtained from adult specimens,² not merely from tentatively identified *Leptocephalus* larvae. It thus seems fairly certain that at least two entirely distinct species have heretofore been confused under the name of *Ilyophis brunneus*. Since, however, the material on hand only includes a typical representative of the original species, the author shall refrain from naming the other form in this report. The table of measurements on page 36 may aid in the further study of these fishes.

Only 133 pores are found in the lateral line of the specimen on hand, while 145 have been counted in the type. The lateral line ends a short distance³ in advance of the end of the tail in both specimens. The accompanying figure 15 shows the dentition of the type specimen drawn from a wax imprint supplied by the U. S. National Museum.

The specimen in the Bingham Oceanographic Collection is a mature female with ripe eggs.

Family SYNAPHOBANCHIDAE

Genus *Synaphobranchus* Johnson

Synaphobranchus pinnatus (Gronovius)

10 specimens, No. 2734 B. O. C. Station 20, March 11, 1927. N. $23^{\circ} 54' 20''$.

W. $77^{\circ} 09'$. 8000 feet wire. 710-720 fathoms depth.

8 specimens, No. 2735 B. O. C. Station 54, April 12, 1927. N. $21^{\circ} 15' 40''$.

W. $71^{\circ} 17' 06''$. 7500 feet wire. 900-955 fathoms depth.

The above two samples of this species were both obtained in bottom hauls with an otter trawl.

¹ The writer has not had access to Lea's paper.

² The figures being given under the heading of: "Species, the larval stages of which are not yet identified."

³ About 4.5-6 per cent of the length.

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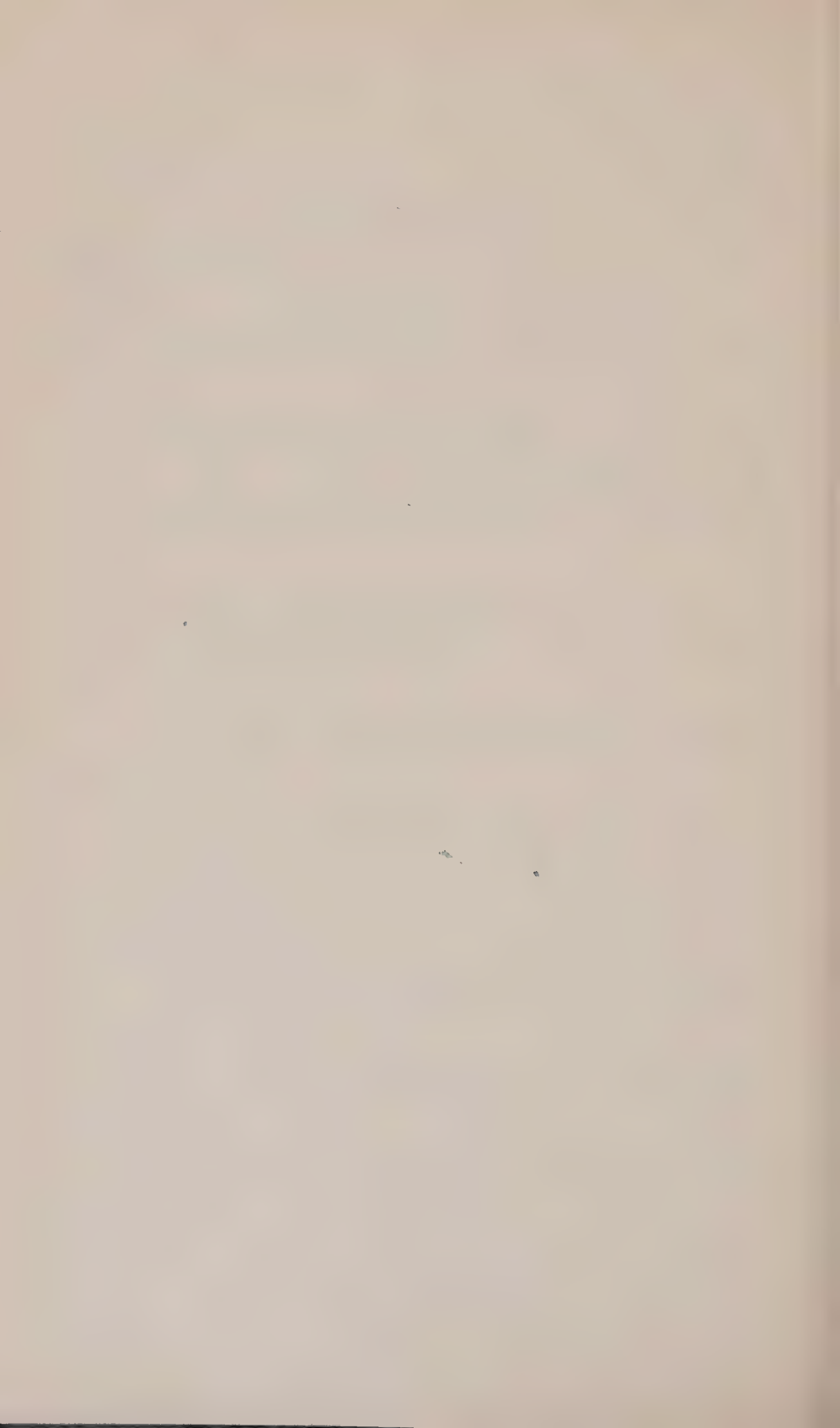
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SCIENTIFIC RESULTS OF THE THIRD OCEANOGRAPHIC
EXPEDITION OF THE "PAWNEE"
1927

DEEPSEA BERYCOMORPHI AND PERCOMORPHI
FROM THE WATERS AROUND THE BAHAMA
AND BERMUDA ISLANDS

BY ALBERT EIDE PARR

INTRODUCTION

The present account is the sixth in a series of reports dealing with the fishes collected during the third oceanographic expedition of the "Pawnee," under the sponsorship and direction of Harry Payne Bingham. Two new families, six new genera, and eleven new species are introduced in this article, as listed below. All illustrations except figure 4 are reproduced from drawings prepared by Mr. Yngve H. Olsen, Assistant in the Bingham Oceanographic Laboratory.

NEW FAMILIES, GENERA AND SPECIES

GIBBERICHTHYIDAE, new family (*Berycomorphi*)

GIBBERICHTHYS, new genus

Gibberichthys pumilus, new species

KORSOGASTERIDAE, new family (*Berycomorphi*)

KORSOGASTER, new genus

Korsogaster nanus, new species

Melamphaes opisthopterus, new species (*Berycomorphi*, *Melamphaidae*)

BRINKMANNELLA, new genus (*Percomorphi*, *Chilodipteridae*)

Brinkmannella elongata, new species

BATHYSPHYRAENOPS, new genus (*Percomorphi*, *Chilodipteridae*)

Bathysphyraenops simplex, new species

ERYTHROBUSSOTHEN, new genus (*Percomorphi*, *Chilodipteridae*)

Erythrobussotheren gracilis, new species

Hemicyclodon macrurus, new species (*Percomorphi*, *Chiasmodontidae*)

Pseudoscopelus altipinnis, new species (*Percomorphi*, *Chiasmodontidae*)

Barathrodemus microps, new species (*Percomorphi*, *Brotulidae*)

Neobythites phyllosoma, new species (*Percomorphi*, *Brotulidae*)

BROTULOTAENIA, new genus (*Percomorphi*, *Brotulidae*)

Brotulotaenia nigra, new species

LIST OF STATIONS

- STATION 5. 2/26, 1927. 25° 56' N. 77° 37' W. 5000 feet wire.
1 *Korsogaster nanus*, n. sp.
1 *Erythrobussothen gracilis*, n. sp.
- STATION 9. 1/3, 1927. 23° 55' N. 77° 09' W. 4000-7000 feet wire.
1 *Melamphaes robustus* Günther 1887
1 *Rondeletia bicolor* Goode and Bean 1895
1 *Galeagra sherborni* (Norman 1929)
1 *Brama raji* (Block 1791)
- STATION 11. 2/3, 1927. 23° 58' N. 77° 26' W. 7000 feet wire.
2 *Caulolepis longidens* Gill 1883
2 *Melamphaes opisthopterus*, n. sp.
3 *Melamphaes mizolepis* (Günther 1878)
1 *Rondeletia bicolor* Goode and Bean 1895
3 *Chiasmodon niger pluriradiatus*, n. subsp.
- STATION 16. 9/3, 1927. 23° 49' N. 76° 58' W. 7000 feet wire.
7 *Melamphaes robustus* Günther 1887
5 *Melamphaes mizolepis* (Günther 1878)
2 *Chiasmodon niger pluriradiatus*, n. subsp.
- STATION 18. 10/3, 1927. 23° 42' N. 76° 43' W. 7000 feet wire.
1 *Caulolepis longidens* Gill 1883
3 *Melamphaes robustus* Günther 1887
4 *Melamphaes mizolepis* (Günther 1878)
1 *Parabrotula dentiens* Zugmayer 1911
11 juvenile *Parabrotula dentiens* Zugmayer 1911
- STATION 20. 11/3, 1927. 23° 54' N. 77° 09' W. 8000 feet wire.
1 *Melamphaes opisthopterus*, n. sp.
1 *Barathrodemus microps*, n. sp.
- STATION 22. 12/3, 1927. 23° 37' 25'' N. 77° 15' 10'' W. 7000 feet wire.
1 *Caulolepis longidens* Gill 1883.
5 *Melamphaes robustus* Günther 1887
1 *Brinkmannella elongata*, n. sp.
1 *Bathysphyraenops simplex*, n. sp.
- STATION 23. 14/3, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.
2 *Melamphaes opisthopterus*, n. sp.
3 *Melamphaes robustus* Günther 1887
1 *Melamphaes mizolepis* (Günther 1878)
1 *Galeagra sherborni* (Norman 1929)
1 *Chiasmodon niger pluriradiatus* n. subsp.
- STATION 25. 17/3, 1927. 24° 51' N. 76° 37' W. 8000 feet wire.
5 *Melamphaes opisthopterus* n. sp.
10 *Melamphaes robustus* Günther, 1887
18 *Melamphaes mizolepis* (Günther)

- 1 *Bathysphyraenops simplex* n. sp.
1 *Dysalotus alcocki* McGilchrist 1905
1 *Pseudoscopelus altipinnis* n. sp.
- STATION 31. 21/3, 1927. 24° 29' N. 75° 53' W. 7000 feet wire.
2 *Melamphaes opisthopterus*, n. sp.
4 *Melamphaes mizolepis* (Günther 1878)
1 *Rondeletia bicolor* Goode and Bean 1895
- STATION 33. 22/3, 1927. 24° 11' N. 75° 37' W. 8000 feet wire.
1 *Melamphaes microps microps* Günther 1878
1 *Melamphaes microps longivelis*, new subsp.
7 *Melamphaes robustus* Günther 1887
1 *Brama raji* (Block 1791)
- STATION 39. 29/3, 1927. 22° 42' 33'' N. 74° 23' W. 8000 feet wire.
3 *Melamphaes opisthopterus*, n. sp.
3 *Melamphaes robustus* Günther 1887
1 *Melamphaes cristiceps* Gilbert 1891
14 *Melamphaes mizolepis* (Günther 1878)
2 *Rondeletia bicolor* Goode and Bean 1895
- STATION 41. 30/3, 1927. 22° 31' N. 74° 26' W. 10,000 feet wire.
1 *Melamphaes microps longivelis*, n. subsp.
1 *Melamphaes opisthopterus*, n. sp.
1 *Melamphaes robustus* Günther 1887
2 *Rondeletia bicolor* Goode and Bean 1895
1 *Hemicyclodon macrurus*, n. sp.
- STATION 46. 4/4, 1927. 21° 46' 12'' N. 72° 49' 30'' W. 10,000 feet wire.
3 *Melamphaes opisthopterus*, n. sp.
3 *Melamphaes robustus* Günther 1887
1 *Melamphaes mizolepis* (Günther 1878)
- STATION 47. 5/4, 1927. 21° 43' 55'' N. 72° 41' 20'' W. 3500 feet wire.
2 *Diretmus argenteus* Johnson 1863
- STATION 48. 6/4, 1927. 21° 44' N. 72° 43' 25'' W. 7000 feet wire.
1 *Gibberichthys pumilus*, n. sp.
1 *Caulolepis longidens* Gill 1883
3 *Melamphaes mizolepis* (Günther)
1 *Rondeletia bicolor* Goode and Bean 1895
1 *Bathysphyraenops simplex*, n. sp.
1 *Pseudoscopelus scriptus* Lütken 1892
1 *Pseudoscopelus altipinnis*, n. sp.
- STATION 52. 11/4, 1927. 21° 30' N. 71° 11' W. 8000 feet wire.
6 *Melamphaes robustus* Günther 1887
3 *Melamphaes mizolepis* (Günther 1878)
1 *Brotulotaenia nigra*, n. sp.
1 *Neobythites phyllosoma*, n. sp.

STATION 54. 12/4, 1927. 21° 15' 40'' N. 70° 17' 06'' W. 7500 feet wire.

1 *Barathrites iris* Zugmayer 1911

STATION 56. 13/4, 1927. 21° 20' N. 71° 13' W. 6500 feet wire.

1 *Melamphaes microps*, subsp.?

9 *Melamphaes mizolepis* (Günther 1878)

5 *Rondeletia bicolor* Goode and Bean 1895

STATION 58. 20/4, 1927. 32° 24' N. 64° 29' W. 10,000 feet wire.

14 *Melamphaes microps microps* Günther 1878

1 *Melamphaes lugubris* Gilbert 1890, subsp.?

35 *Melamphaes opisthopterus*, n. sp.

1 *Melamphaes robustus* Günther 1887

10 *Melamphaes triceratops* Roule and Angel 1933

1 *Melamphaes mizolepis* (Günther)

1 *Chiasmodon niger* Johnson 1863

STATION 59. 21/4, 1927. 32° 19' N. 64° 33' W. 8000 feet wire.

1 *Anoplogaster cornutus* (Cuvier & Valenciennes)

3 *Melamphaes microps* subsp.?

5 *Melamphaes opisthopterus*, n. sp.

2 *Melamphaes robustus* Günther 1887

7 *Melamphaes triceratops* Roule and Angel 1933

1 *Chiasmodon niger* Johnson 1863

Order BERYCOMORPHI

Due to inadequate material for anatomical investigation our knowledge of the systematic relationships of the deepsea members of the Berycomorphi is unfortunately still most incomplete in spite of the excellent foundation laid by Regan (1911). To make a clear-cut division into suborders seems impossible at the same time as various of the families now recognized seem to be rather of subordinal than family rank judged by the diversity of forms they embrace. An increase of the number of families therefore seems advisable as a preliminary step towards the classification of the subordinal relationships. Thus the Melamphaidae of Regan has in the following been split into the Melamphaidae *sensu stricto*, embracing *Melamphaes*, *Plectromus* and *Scopelogadus*, and the Caulolepidae, embracing *Caulolepis* and *Anoplogaster*. The Korsogasteridae has been introduced for *Korsogaster* and *Leiogaster*, apparently nearly related to the Trachichthyidae but without the keeled abdominal scales characteristic of the latter family. The Rondeletiidae seem fairly close to the Melamphaidae. The Gibberichthyidae represent an entirely new type of deepsea berycomorphi.

GIBBERICHTHYIDAE, new family

Dorsal and anal fins with a few thick, graduated spines. Ventral fins small, with one spine and 5 rays, subabdominal, that is, at the end of the strongly

developed pelvic bones well behind the pectoral fins. Caudal with 19 main rays. Jaws with villiform teeth in bands. No canines. Vomer and palatines toothless. Upper edge of maxillary slipping under preorbital and anterior suborbitals. Head enormous, very cavernous, with spiniferous crests. Body short by not very high. Scales rather large, deciduous. Abdomen without scaly keel. No subocular organ. Pyloric ceca moderately numerous. Pseudobranchiae present. A small opening behind the fourth gill arch. Black deepsea fishes.

The lack of resemblance between *Gibberichthys pumilus* n. gen. et sp. and any of the previously known forms of berycomorph fishes which will be apparent from the figure and description of the new species given on the following pages makes it very difficult to discern its particular affinities within the order Berycomorphi as a whole.¹ It seems to occupy a rather isolated position and the introduction of a new family, at least, seems fully warranted by the character of its general appearance. It is unfortunate, however, that the existence of only one single, small specimen in the available collections does not make an anatomical investigation possible and therefore only permits of a provisional and rather incomplete definition of the new family.

Gibberichthys, new genus

Body very short, but not particularly high and compressed; with deciduous scales of moderate size, those of the lateral line enlarged (around 30). Head enormous; cavities covered by skin with very wide simple pores; crests and ridges spiny. Preoperculum with spines both along its anterior and its posterior free edge. Operculum with a broad, flat, inconspicuous spine. Sub- and interoperculum smooth. A broad double-pointed spine in the scapular region (on supracleithrum or posttemporal). Eyes moderate or large. Mouth very large, only moderately oblique. Teeth minute, in 2 or 3 irregular rows in each jaw. No canines. Vomer and palatines toothless. Dorsal with 5 very thick graduated spines and about 9 soft rays. Anal with 3 thick graduated spines and about 9 rays. Caudal moderate, slightly forked, with rounded lobes. Ventrals very small, with rather thick skin. Pectorals moderate, about 14 rays. Gill rakers in first arch long, about 14 in the lower part. Pyloric ceca 10.

Other characters as in the family diagnosis.

Gibberichthys pumilus n. sp.

1 specimen, No. 2838 B. O. C. TYPE. Station 48, 6/4, 1927. N. 21° 44'. W. 72° 43' 25". 7000 feet wire.

Length without caudal fin 31.5 mm. Proportions in per cent of the length without caudal fin: Length of head 46. Length of snout 13. Diameter of eye

¹ In placing the new form with the Berycomorphi the author has also had the benefit of the opinions expressed by Messrs. C. T. Regan and J. R. Norman after inspection of the specimen.

11. Interorbital width 18. Length of maxillary 25.5. Length of lower jaw 28.5. Snout to first dorsal spine 57. Snout to first dorsal ray 67. Snout to anal fin 61. Greatest depth of body 36. Least depth of caudal peduncle 10. Distance from the end of dorsal or anal finbase to base of middle caudal rays 21. Length of pectorals 21. Length of ventrals 8. Length of caudal 26.

D. VI 9. A. III 9. P. 14. V. I 5. Gill rakers 6/14. Pseudobranchiae with about 8 rather feeble lamellae. Caudal with 19 main rays. 29 enlarged scales in lateral line.

The five anterior spines in dorsal fin are very broad and thick, free from fin membrane, with the first two barely showing their points above the skin. Sixth dorsal spine more slender and elongate. The three anal spines are similar to the five first dorsal spines, short, very thick, and free from the fin membrane. Soft rays of all fins simple. Caudal with 8 procurent spines above and 7 below. Ventrals thickskinned and stubby.

Posterior free edge of preoperculum with a series of four spines rounding the corner; anterior edge with 3-5 major spines at the corner, with some minor spines above and below. Angular with a ventral spine continuing the posterior preopercular series. Ventral edge of lower jaw with 3 minute spines in a group before the angular spine and with a series of similar minute spines on the anterior third. Head with spiny circumorbital, nasal and frontal crests with large cavities between, roofed by skin, with simple wide pores, the numbers and arrangements of which are shown in the figure. Sphenotic region with two spines. Snout deeply concave in profile, flat in cross section, due to the flat skin stretched between the nasal crests. Skin on the back between head and dorsal fin protruding sharply at two points, apparently due to special elevation of two of the neural spines.

Scales all missing but scale pockets distinct; those of the lateral line greatly enlarged, the others small. Squamation in the thoracic region apparently incomplete although a few scattered scales would seem to have been present.

Color uniformly black.

Family **DIRETMIDAE**

Genus **Diretmus** Johnson 1863

Diretmus argenteus Johnson 1863

2 specimens No. 2799 B. O. C. Station 47, April 5, 1927. 21° 43' 55' N. 72° 41' 20" W. 3500 feet wire.

Since the above two specimens are less than half the length of the smallest ones previously recognized and reported upon¹ and show several juvenile or permanent features, which have heretofore remained unaccounted for in the literature, a brief description and illustration (fig. 2) may be in place.

¹ Roule and Angel, 1930, p. 78, Pl. IV, fig. 100. One specimen 23 mm. long.

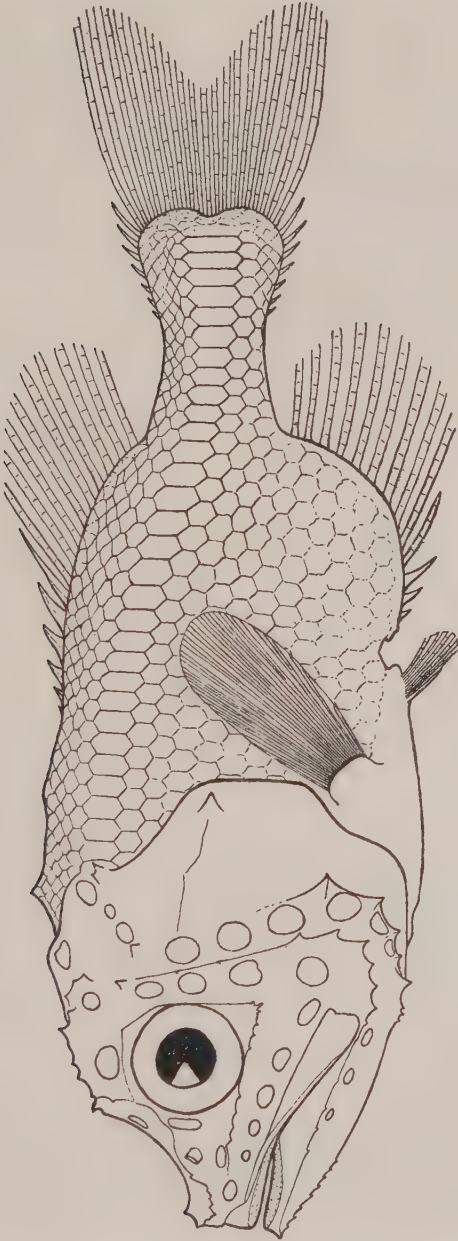


Figure 1. *Gibberichthys pumilus* n. sp. Drawn by Y. H. Olsen.

Both specimens measure about 11 mm. exclusive of the caudal fin. Proportions of one of the specimens in per cent of this measurement: Greatest depth 65. Length of head 45. Diameter of eye 18. Length of maxillary 28. Length of caudal fin 34. Length of pectorals 36. Length of ventrals 41. Base of dorsal fin 43. Base of anal 32. Length of caudal peduncle 13. Least depth of caudal peduncle 9. Snout to dorsal fin 55. Snout to ventrals 73. Snout to anal fin 85. Cephalic spine 14.

Counts (both specimens): D. 24-25. A. 22 ($21\frac{1}{2}$). P. 18.

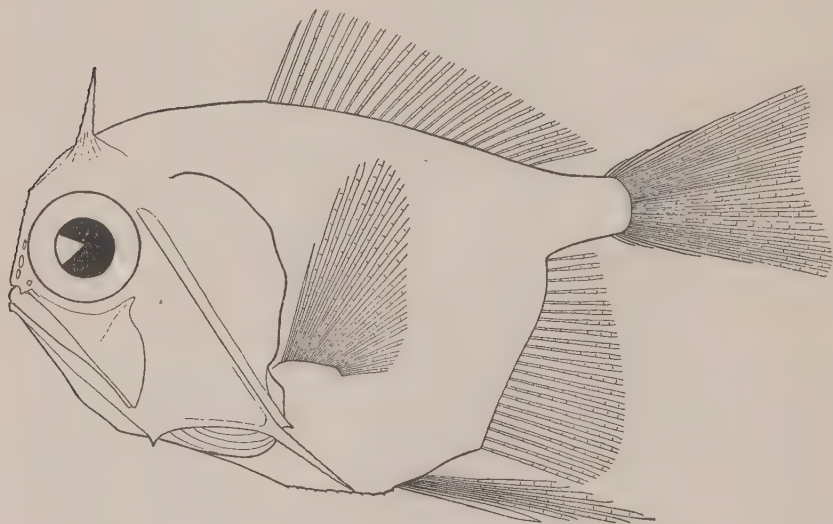


Figure 2. *Diretmus argenteus* Johnson. Drawn by Y. H. Olsen.

A prominent feature of the two specimens on hand is the great development of the cephalic and preopercular spines, which, in addition to the pronounced skewness of the general body form, lends emphasis to the general similarity existing between this species and such other types of beryciform fishes as *Anoplogaster* (see figure 5) and related forms. While there can be no question that a separate family for the genus *Diretmus* is fully justified, the writer is of the opinion that the Diretmidae together with the Trachichthyidae and the Caulolepidae form a rather closely related natural group for which a separate suborder, the Trachichtyoidea, might be in place.

None of the articulated rays in any of the fins, including the caudal, show any signs of branching as yet in the two specimens on hand. A special feature is also contributed by a strong spine-like projection from the dorsal margin of the maxillary immediately below the eye, in continuation of a slight transverse ridge (see fig. 2).

Family **KORSOGASTERIDAE****Korsogaster** new genus

Body high, compressed; without normal scales but thickly covered with small, slender, simple spines giving the skin a furry appearance. Head very large, cavernous; simple, minute spines in a single series covering the exposed free edges of most of its bony crests. Preopercle with large spines in addition to the minute ones. Mouth large, very oblique. Maxillary exposed and expanded posteriorly. Teeth very small, no canines. Eye moderate. Gill openings very wide. Gill rakers long, in moderate numbers (about 13 in lower part of anterior arch). 8 branchiostegal rays. Pyloric ceca numerous (order of magnitude of number around 40). A small opening behind the fourth gill arch. Pseudobranchiae well developed. A single dorsal fin with 5 spines and about 14 soft rays. Anal with 2 spines and about 11 soft rays. Ventrals with 1 spine and 6 rays. Pectorals moderate. Caudal moderately forked with rounded lobes and procurrent spines; 19 main rays. Vent immediately in advance of anal fin.

Genotype, *Korsogaster nanus* n. sp.

In general appearance the new genus shows a fairly close resemblance to *Leiogaster* Weber, from which, however, it differs in the absence of scales and the development of dermal spines in their place; in the presence of an opening behind the fourth gill arch; and in various other details.

Korsogaster nanus n. sp.

1 specimen No. 2839, B. O. C. TYPE. Station 5, 2/26, 1927. 25° 56' N. 77° 37' W. 5000 feet wire.

Length without caudal fin 18 mm. Proportions in per cent of length without caudal fin: Length of head 44. Greatest depth of body 48. Least depth of caudal peduncle 11. Diameter of eye 11. Length of snout 9.5. Length of maxillary 25. Length of lower jaw 29. Interorbital width 13. Snout to dorsal fin 51. Snout to anal fin 70. Length of pectorals 26. Length of ventrals 23. Length of caudal fin 36. Base of dorsal fin to base of middle caudal rays 23. Base of anal fin to base of middle caudal rays 20. Dorsal fin base 40. Anal fin base 16.

D. V + 14 (12 branched). A. II + 11 (10 branched). P. 17 (all unbranched). V. I + 6. Caudal with 19 main rays, all simple. Br. 8. Gill rakers 6/13 in first arch. Pseudobranchiae large, about 10 fully developed lamellae in each.

Pectoral, ventral and caudal rays all unbranched in the type, although some of the caudal rays show indications of a beginning division at their tips. Possibly the simple character of so many of the rays is only a juvenile feature.

Maxillary extending slightly beyond the posterior margin of the eye. Pre-

opercle with a large spine at the corner; and with three projections along its posterior margin above, each complicated by minute secondary spines (see figure). Interoperculum with two broad spine-like projections. Angular sharp and prominent. Operculum with two denticulated ridges which do not end in spines at the edge and do not radiate from a common base, the upper ridge on the contrary diverging from the lower, horizontal one a short distance away from its origin (see figure). Operculum also covered with a number of minute spines and dermal papillae on its lower portion. Two minute denticulated ridges crossing the exposed posterior portion of the maxillary. The complex system of denticulated crests is otherwise best seen from the illustration.

In addition to the free spines there are also a number of dermal papillae scattered over the head and body, each apparently associated with an unexposed spine. In some cases the papillae are probably only dermal protuberances caused by the growing spines; but in other instances they have a definite, swollen, somewhat fungiform shape suggesting that they may have a functional significance of their own, probably of a sensory nature. These swollen papillae are particularly conspicuous in the lateral line region where they form a pattern of short, rather irregular vertical rows, about 27 in number.

There is an irregular band of minute teeth in each jaw, those of the premaxillaries to a considerable extent external in position. The author has not been able to determine definitely whether vomer and palatines are toothless, or whether there is a very feeble dentition present on these bones.

Color light gray. Caudal with extreme end of caudal peduncle white (colorless). Ventrals black.

Family **CAULOLEPIDAE**

Genus **Caulolepis** Gill 1883

Caulolepis longidens Gill 1883

- 2 specimens, No. 2845 and 2857, B. O. C. Station 11, 2/3, 1927. N. 23° 58'. W. 77° 26', 7000 feet wire.
1 specimen, No. 2844, B. O. C. Station 18, 10/3, 1927. N. 23° 42'. W. 76° 43', 7000 feet wire.
1 specimen, No. 2843, B. O. C. Station 22, 12/3, 1927. N. 23° 37' 25". W. 77° 15' 10", 7000 feet wire.
1 specimen, No. 2846, B. O. C. Station 48, 6/4, 1927. N. 21° 44'. W. 72° 43' 25", 7000 feet wire.

Genus **Anoplogaster** Günther 1859

Anoplogaster cornutus (Cuvier & Valenciennes)

- 1 specimen, No. 2797 B. O. C. Station 59, 4/21, 1927. 32° 19' N. 64° 33' W. 8000 feet wire.

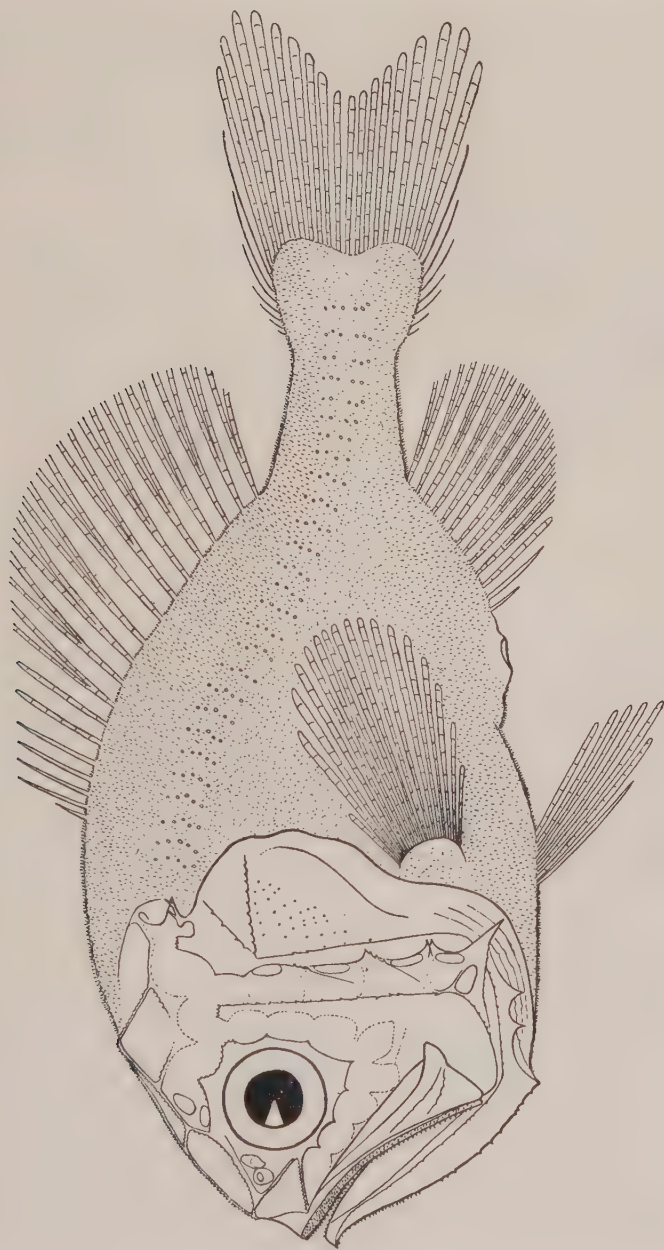


Figure 3. *Korsogaster nanus* n. sp. Drawn by Y. H. Olsen.

Length without caudal fin 25.5 mm. Proportions in per cent of the length without caudal fin: Length of head 45. Depth of head (greatest depth of specimen) 63. Depth of caudal peduncle 11. Length of caudal peduncle 14. Diameter of eye 13. Length of maxillary 31. Length of lower jaw 33. Inter-orbital width 16. Cephalic spine 9.5. Preopercular spine 8. Snout to dorsal fin 55. Snout to ventral fins 61. Snout to anal fin 86. Base of dorsal fin 35. Base of anal fin 9.5. Length of caudal fin 25.

D. $18\frac{1}{2}$. A. $8\frac{1}{2}$. P. 14, the upper ray very short. V. 7.

From the counts and measurements given above, it will be seen that the specimen on hand differs from the earlier descriptions by having $1\frac{1}{2}$ more rays

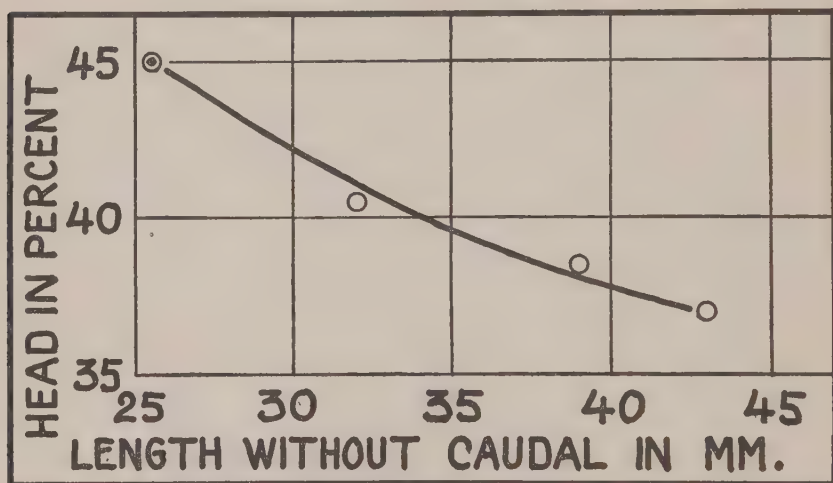


Figure 4. Decrease in relative size of head with increasing total length in *Anoplogaster cornutus*. Open rings for measurements recorded by Lütken. * Ring and dot for proportions of specimen on hand.

in the dorsal fin, 2 rays less in the pectorals, and a considerably larger head than previously recorded for this species. To study the significance of the latter feature, which would seem to be the most important distinguishing character of the specimen on hand, the measurements recorded by Lütken (1878, p. 185) have been graphically compared with the proportions of the specimen here reported upon in the accompanying figure 4. From this illustration it will be seen that these various specimens form a very natural series, with their proportions fitting easily into a reasonable ontogenetic curve of decreasing relative size of the head with increasing absolute length of the specimen. With the taxonomic significance of its larger head thus entirely discounted by this comparison, the differences in the fin counts were not considered sufficiently im-

portant to warrant any doubt about the identity of the specimen here reported upon with the previously known species. The accompanying figure 5 has been

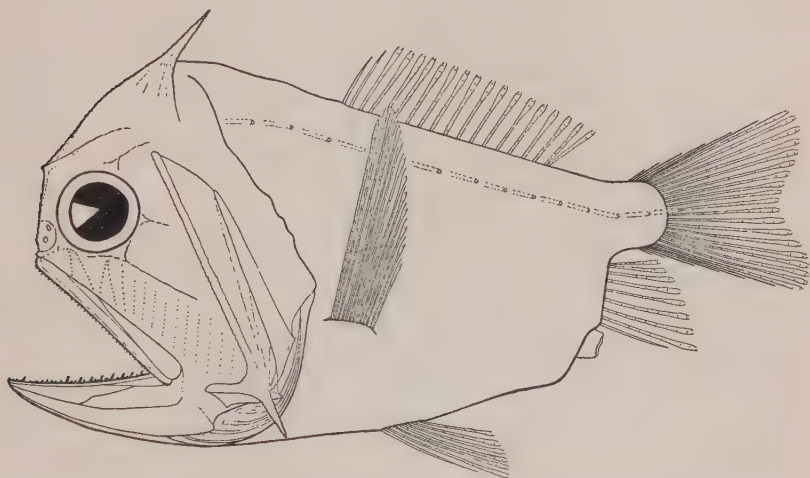


Figure 5. *Anoplogaster cornutus* (Cuvier & Valenciennes). Drawn by Y. H. Olsen.

prepared mainly to show the essential skewness of this species in lateral view, a feature which has not been properly brought out in any of the earlier illustrations (Lütken, 1878, pl. V, fig. 4; Goode and Bean, 1896, fig. 203.).

Family **MELAMPHAIDAE**

Genus **Melamphaes** Günther 1864

In the following key the synopsis of the species published by Norman (1929 b, p. 155) has been expanded to include the new species described in the present report or otherwise introduced subsequent to the publication of Norman's paper.

Key to the Species

I. More than 20 scales in a longitudinal series.

A. No spine on the snout between the nostrils; (origin of anal below last two or three rays of dorsal or farther back).

1. Dorsal with 17 to 21 (II-III 14-18) rays.

a. 8 or 9 gill rakers on lower part of anterior arch. Head $3\frac{1}{2}$ in length without caudal. Origin of anal well behind last ray of dorsal.....1. *typhlops*.

b. 13 to 17 gill rakers on lower part of anterior arch. Origin of anal below or immediately behind last ray of dorsal.

- x. Head $2\frac{2}{3}$ to $3\frac{1}{2}$ in the length without caudal; origin of pelvic below or a little behind pectoral base; eye 5 to $6\frac{3}{4}$ in head. D. III 15-18. 2. *microps*.
- xx. Head $2\frac{1}{2}$ in the length without caudal; origin of pelvic a little in front of pectoral base. Eye 6 to $6\frac{1}{2}$ in head, $1\frac{1}{2}$ in snout. 3. *lugubris*.
- xxx. Head only 2 to $2\frac{1}{3}$ in length without caudal. Origin of pelvic a little in front of pectoral base. Eye $8\frac{2}{5}$ to $9\frac{2}{5}$ in head, 2 to $2\frac{1}{5}$ in snout. 4. *macrocephalus*.¹
- 2. Dorsal with 12 to 15 (II-III 9-12) rays.
 - a. Dorsal III 9; diameter of eye $4\frac{2}{5}$ to $5\frac{1}{2}$ in head; maxillary extending to below middle of eye or a little beyond. 5. *nordenskjoldi*.
 - b. Dorsal II-III 11-12; diameter of eye 8-11 in head; maxillary extending beyond posterior margin of eye.
 - x. Length of head 3 to $3\frac{1}{2}$ in length without caudal. Origin of pelvics far behind pectoral base. 6. *opisthopterus* n. sp.
 - xx. Length of head $2\frac{2}{3}$ to $2\frac{1}{2}$ in length without caudal.
 - o. Origin of pelvic distinctly behind pectoral base; snout $3\frac{1}{2}$ to 4, diameter of eye 8 to 11 in head. 7. *robustus*.
 - oo. Origin of pelvic below or immediately behind pectoral base; snout $3\frac{2}{3}$, diameter of eye about 11 in head. 8. *nigrescens*.²
- B. A spine on the middle of the snout between the nostrils or anterior parts of the eyes; origin of anal below posterior half of dorsal.
 - 1. Origin of pelvic a little in front of pectoral base; caudal peduncle 4 to $4\frac{1}{2}$ times as long as deep; diameter of eye $3\frac{1}{2}$ to $3\frac{3}{4}$ in head. 9. *megalops*.
 - 2. Origin of pelvic slightly in front of pectoral base; caudal peduncle 2 to $2\frac{1}{2}$ times as long as deep; diameter of eye $8\frac{1}{2}$ to $9\frac{1}{2}$ in head; head 2 to $2\frac{1}{3}$ in length without caudal; interorbital width 4 to $4\frac{1}{2}$ in head. 4. *macrocephalus*.³
 - 3. Origin of pelvic below or a little behind pectoral base; caudal peduncle $2\frac{1}{4}$ to 3 times as long as deep.
 - a. Dorsal III 12-15; origin nearer end of snout than base of caudal. Interorbital width $3\frac{1}{4}$ to $3\frac{1}{2}$ in head.

¹ Parr 1931, p. 41, fig. 16.² Possibly synonymous with *robustus*. See page 20.³ Parr 1931, p. 41, fig. 16.

- x. Diameter of eye 7 to $8\frac{1}{2}$ in head. Maxillary extending to a little beyond the posterior margin of the eye. Head $2\frac{1}{4}$ to $2\frac{2}{3}$ in length without caudal.
 - o. Head $2\frac{2}{3}$ to $2\frac{2}{3}$ in the length without caudal, last ray of dorsal behind vertical from middle of anal finbase; caudal peduncle $2\frac{1}{2}$ to $2\frac{2}{3}$ times as long as deep10. *cristiceps*.
 - oo. Head nearly 3 in the length; last ray of dorsal a little in front of vertical from middle of anal; caudal peduncle nearly 3 times as long as deep.
 - 11. *crassiceps*.
 - xx. Diameter of eye $5\frac{2}{3}$ to $6\frac{1}{2}$ in head. Maxillary extending to below posterior $\frac{1}{4}$ of eye. Head nearly 3 in length without caudal. Caudal peduncle nearly 3 times as long as deep.....12. *atlanticus*.
 - b. Dorsal III 10-12; origin a little nearer base of caudal than end of snout. Caudal peduncle $2\frac{1}{3}$ to $2\frac{1}{2}$ times as long as deep. Head $2\frac{1}{4}$ to $2\frac{1}{2}$ in length without caudal.
 - x. Interorbital width about 3 or less, eye 6 in head.
 - 13. *nigrofulvus*.
 - xx. Interorbital width about $4\frac{2}{3}$, eye 7 in head.
 - 14. *unicornis*.
 - c. Dorsal III 10-11; origin nearer end of snout than base of caudal. Frontal crests each with a prominently projecting horizontal spine anteriorly. Head $2\frac{1}{4}$ to $2\frac{2}{3}$ in length without caudal. Caudal peduncle about $2\frac{1}{3}$ times as long as deep.....15. *triceratops*.
- II. Less than 20 scales in a longitudinal series.
- A. Head only 2 to $2\frac{1}{3}$ in length. Diameter of eye 8 to 9, length of snout about $3\frac{1}{2}$ to $4\frac{1}{2}$ in head.....16. *bispinosus*.¹
 - B. Head about $2\frac{1}{2}$ to a little more than 3 in length. Diameter of eye less than 8 in head.
 - 1. Anterior profile strongly arched; height of head (at level of preopercular ridge) $1\frac{1}{2}$ to $1\frac{1}{4}$ in its length; diameter of eye $4\frac{1}{2}$ to $5\frac{1}{2}$ in head, length of snout $4\frac{2}{3}$ to 5.....17. *beanii*.
 - 2. Anterior profile angular; height of head (at level of preopercular ridge) $1\frac{1}{2}$ to $1\frac{3}{4}$ in its length; diameter of eye $5\frac{1}{5}$ to $7\frac{3}{4}$ in head, length of snout $3\frac{1}{2}$ to $4\frac{1}{2}$18. *mizolepis*.

Melamphaes microps Günther 1878

In the material here combined under the specific designation of *M. microps*, there is a sufficiently strong suggestion of heterogeneity to make it seem ad-

¹ See Parr 1931, p. 43, fig. 17.

visible to introduce subspecific distinctions. In the measurements given in the accompanying table, we find the specimens designated as subsp. *longivelis* showing a rather distinctly shorter caudal peduncle, and also a tendency to somewhat larger heads and eyes and a slightly higher dorsal fin count. The first of these characters seem particularly valuable and does not show any signs of intergradations even in the two questionable specimens which would seem to form intergradations in most other respects. Due to the small size of all specimens, however, it is difficult to elaborate such comparisons of proportions any further, and it must suffice at the present time to have pointed out the possibility of a taxonomic distinction based upon proportions until larger specimens may become available for study.

M. microps microps Günther 1878

1 specimen, No. 2831 B. O. C. Station 33 22/3, 1927. N. 24° 11'. W. 75° 37'. 8000 ft. wire.

14 specimens, No. 2830 B. O. C. Station 58, 20/4, 1927. N. 32° 24'. W. 64° 29', 10,000 ft. wire.

Caudal peduncle, measured from base of anal to base of middle caudal rays contained about 4 times or less (24 to 27 per cent) in the length without caudal.

M. microps longivelis n. subsp.

1 specimen, No. 2834, B. O. C. Station 33, 22/3, 1927. N. 24° 11'. W. 75° 37'. 8000 ft. wire.

1 specimen, No. 2833, B. O. C. TYPE. Station 41, 30/3, 1927. N. 22° 31'. W. 74° 26'. 10,000 ft. wire.

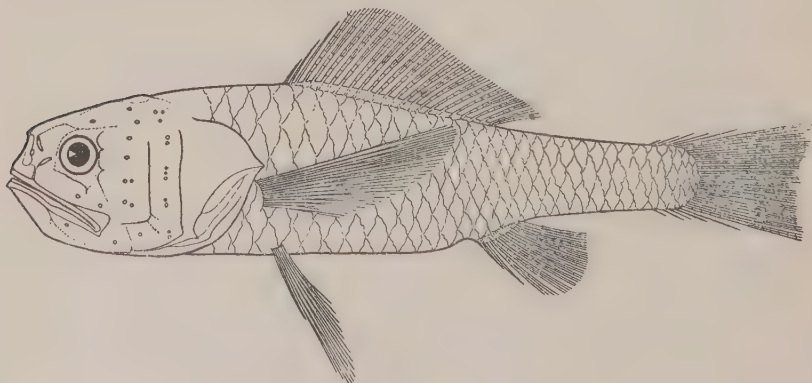


Figure 6. *Melamphaes microps longivelis* n. subsp. Drawn by Y. H. Olsen.

Caudal peduncle, measured from base of anal to base of middle caudal rays contained about 5 times (19 to 20 per cent) in the length without caudal.

M. microps subsp.?

1 specimen, No. 2835, B. O. C. Station 56, 13/4, 1927. N. 21° 20'. W. 71° 13'. 6500 ft. wire.

3 specimens, No. 2836, B. O. C. Station 59, 21/4, 1927. N. 32° 19'. W. 64° 33'. 8000 ft. wire.

Species			<i>microps</i>				<i>lugubris</i>
Station No.	41	33	58	58	59	59	58
Subspecies	<i>longivelis</i>		<i>microps</i>		?	?	?
Length without caudal fin in mm.	43	20.5	21	20.5	20.5	28	20.5
Proportions in per cent of length without caudal fin:							
Length of head	38	40	35	35	36	38	42
Diameter of eye	6.0	8.0	4.5	5.0	5.0	6.0	9.0
Length of snout	7.5	8.5	8.5	9.5	7.5	8.5	8.5
Length of maxillary	18	20	17	17	16	17	19
Interorbital width	12.5	13	14	13	12.5	13.5	13
Snout to Dorsal	43	46	43	44	42	43	44
Snout to Anal	71	71	65	68	68	[63]	73
Base of Dorsal to base of middle caudal rays	28	30	30	32	31	34	33
Base of Anal to base of middle caudal rays	20	19	26	24	27	27	26
Dorsal fin base	30	30	30	30	27	28	24
Anal fin base	8	10	10.5	10	9.5	9.5	9.5
Greatest depth of body	25	27	27	26	29	28	26
Least depth of caudal peduncle	9.5	9.0	9.5	9.5	12	11	9.5
Length of Pectorals	30	32	30	31	29	31	30
Length of Ventrals	23	29	22	24	21	24	24
D	III 17½	III 17½	III 15½	III 15½	III 15½	III 16½	III 14½

Melamphaes lugubris Gilbert 1890 subsp.?

1 specimen, No. 2832, B. O. C. Station 58, 20/4, 1927. N. 32° 24'. W. 64° 29'.

The above recorded specimen is identified as *M. lugubris* (subsp.?) on the strength of (1) the position of the ventrals, the pectorals being inserted above the posterior ½ of the ventral fin bases, the anterior ventral rays thus being distinctly in advance of the pectorals, (2) the size of the head, which is contained at little less than 2½ times in the length without caudal, and (3) the dorsal fin count of III 14½.¹ The various measurements of the specimen are given in the table above. From this table it will also be seen, however, that the eyes of the specimen on hand (less than 5 in head) are considerably larger than previously recorded for *M. lugubris*, but this difference must be seen in relation to the fact that the type and only specimen previously recorded measured 90 mm., while the specimen on hand is only 20.5 mm. long. In view of this difference in size, the difference in the proportions of the eyes loses all significance until specimens of similar size can be compared.

¹ The two posterior rays originating from the same pterygiophore being counted as 1½

Norman (1929, p. 158) expresses his doubts as to the distinctness of *M. lugubris* from *M. microps*; but if the specimen here reported upon is a true representative of the former species, there can hardly be any doubt as to its validity. This will become particularly apparent when the specimen is compared with the two specimens of *M. microps microps* of the same size and from the identical haul (Station 58), whose measurements are also given in the table on page 17. It will be seen that our *M. lugubris* is very sharply distinguished by its larger head, much larger eyes and shorter dorsal fin base (figures rendered in bold print in the table to simplify comparison). These differences are all very conspicuous also by a visual inspection of the specimens.

Melamphaes opisthopterus n. sp.

- 2 specimens, No. 2823, B. O. C. Station 11, 2/3, 1927. N. 23° 57' 45". W. 77° 26' 25". 7000 ft. wire.
- 1 specimen, No. 2815, B. O. C. Station 20, 11/3, 1927. N. 23° 54' 10". W. 77° 09'. 8,000 ft. wire.
- 2 specimens, No. 2822, B. O. C. Station 23, 14/3, 1927. N. 24° 29'. W. 77° 29'. 8,000 ft. wire.
- 5 specimens, No. 2817, B. O. C. Station 25, 17/3, 1927. N. 24° 51'. W. 76° 37'. 8,000 ft. wire.
- 1 specimen, No. 2816, B. O. C. TYPE, Station 31, 21/3, 1927. N. 24° 29'. W. 75° 53'. 7,000 ft. wire.
- 1 specimen, No. 2818, B. O. C. Station 31, 21/3, 1927. N. 24° 28' 40". W. 75° 53'. 7,000 ft. wire.
- 3 specimens, No. 2814, B. O. C. Station 39, 29/3, 1927. N. 22° 42' 33". W. 74° 23'. 8,000 ft. wire.
- 1 specimen, No. 2820, B. O. C. Station 41, 30/3, 1927. N. 22° 31'. W. 74° 26'. 10,000 ft. wire.
- 3 specimens, No. 2819, B. O. C. Station 46, 4/4, 1927. N. 21° 46' 12". W. 72° 49' 30". 10,000 ft. wire.
- 35 specimens, No. 2824, B. O. C. Station 58, 20/4, 1927. N. 32° 24' 15". W. 64° 29'. 10,000 ft. wire.
- 5 specimens, No. 2821, B. O. C. Station 59, 21/4, 1927. N. 32° 19'. W. 64° 33'. 8,000 ft. wire.

The type specimen measures 36 mm. without caudal fin and has the following proportions in per cent of this measurement. Length of head 30 per cent. Diameter of eye 3. Length of snout 7.5. Interorbital width 12. Length of maxillary 17. Snout to pectoral fin base 30. Snout to ventral fin base 40. Snout to D 47. Snout to A 65. Base of D to base of middle caudal rays 32. Base of A to base of middle caudal rays 29. Dorsal fin base 24. Anal fin base 7. Greatest depth of body 24. Least depth of caudal peduncle 10. Length of P 25. Length of V 15+.

D. III 12. A. I 8. P. 12. V. I 8. 27-28 scales in a longitudinal series.

Head cavernous, but with smooth ridges. Snout without spine. Opercular and preopercular edges smooth. Maxillary extending considerably behind the posterior margin of the eyes. Gillrakers 3/11 in first arch. Teeth viliform, in narrow bands in each jaw. Anal very short, its origin below the posterior $\frac{1}{4}$ to $\frac{1}{6}$ of dorsal.

The two most characteristic features of this new species are the small size of the head, which has been found to vary in length between 29 and 34 per cent

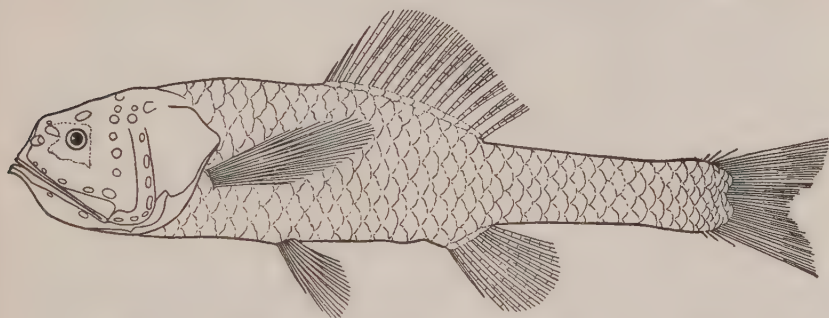


Figure 7. *Melamphaes opisthopectus* n. sp. Drawn by Y. H. Olsen.

of the length without caudal; and the very posterior insertion of the ventrals, their distance from the end of the snout being uniformly about 10 per cent of the length with caudal fin greater than the distance from snout to pectorals in the specimens measured. In some specimens of *M. robustus* measured for comparison, the difference between the distances from snout to pectoral fin and from snout to ventral fin varied between 3 and 6 per cent, only, of the length without caudal, 4-5 per cent being most commonly observed.

***Melamphaes robustus* Günther 1887**

? *Melamphaes nigrescens* Brauer 1906, p. 283, pl. XIII, fig. 4; Norman, 1929, p. 161.

1 specimen, No. 2007, B. O. C. Station 9, 1/3, 1927. N. 23° 55'. W. 77° 09'. 4000-7000 ft. wire.

7 specimens, No. 2802, B. O. C. Station 16, 9/3, 1927. N. 23° 49'. W. 76° 58'. 7000 ft. wire.

3 specimens, No. 2027, B. O. C. Station 18, 10/3, 1927. N. 23° 42'. W. 76° 43'. 7000 ft. wire.

5 specimens, No. 2808, B. O. C. Station 22, 12/3, 1927. N. 23° 37'. W. 77° 15'. 7000 ft. wire.

3 specimens, No. 2807, B. O. C. Station 23, 14/3, 1927. N. 24° 29'. W. 77° 29'. 8000 ft. wire.

- 10 specimens, No. 2805, B. O. C. Station 25, 17/3, 1927. N. 24° 51'. W. 76° 37'. 8000 ft. wire.
- 7 specimens, No. 2810, B. O. C. Station 33, 22/3, 1927. N. 24° 11'. W. 75° 37'. 8000 ft. wire.
- 3 specimens, No. 2806, B. O. C. Station 39, 29/3, 1927. N. 22° 43'. W. 74° 23'. 8000 ft. wire.
- 1 specimen, No. 2009, B. O. C. Station 41, 30/3, 1927. N. 22° 31'. W. 74° 26'. 10,000 ft. wire.
- 3 specimens, No. 2804, B. O. C. Station 46, 4/4, 1927. N. 21° 46'. W. 72° 50'. 10,000 ft. wire.
- 6 specimens, No. 2801, B. O. C. Station 52, 11/4, 1927. N. 21° 30'. W. 71° 11'. 8000 ft. wire.
- 1 specimen, No. 2809, B. O. C. Station 58, 20/4, 1927. N. 32° 24'. W. 64° 29'. 10,000 ft. wire.
- 2 specimens, No. 2803, B. O. C. Station 59, 21/4, 1927. N. 32° 19'. W. 64° 33'. 8000 ft. wire.

The above listed specimens of *M. robustus* are all quite small (less than 40 mm. without caudal), and although they all have their ventrals inserted unmistakably behind the insertion of the pectorals, their proportions intergrade between those of *M. robustus* and *M. nigrescens* (snout $3\frac{2}{3}$ to 4, eyes 8-11 in head).

Under the circumstances, an attempt to maintain a distinction solely on the basis of "origin of pelvic *distinctly behind* pectoral base" or "origin of pelvic below or *immediately behind* pectoral base"¹ would seem very dubious to the writer, who is therefore inclined to believe that the two nominal species will prove to represent only the individual extremes of one and the same form.

Melamphaes cristiceps Gilbert 1891

- 1 specimen, No. 2741, B. O. C. Station 39, March 29. N. 22° 42' 33". W. 74° 23'. 8000 feet wire.

Length without caudal fin 123 mm. Proportions in per cent of the length without caudal fin: Length of head 41. Snout 10.5. Interorbital width 13. Diameter of eye 4.2. Length of maxillary 18. Snout to dorsal fin 46. Snout to anal fin 68. Base of dorsal fin 26. Base of anal 9.8. Dorsal fin base to middle caudal rays 30. Anal fin base to middle caudal rays 24. Depth of caudal peduncle 9.8. Greatest depth of body 27. Length of pectorals 31. Length of ventrals 14.5.

D. III + 11½. A. I + 8½. 24-25 scales in a longitudinal series from the top of the gill slit. About 20 gill rakers in the lower limb of the first arch.

It will be noticed that some of the above measurements and counts extend

¹ Norman 1929, p. 155. Italics here.

the range of variations for the species beyond the limits indicated in Norman's description (Norman, 1929, p. 163), inasmuch as the scales are slightly fewer, and the eyes a little smaller than previously recorded. Beyond extending the range of variations, however, these deviations are quite insignificant.

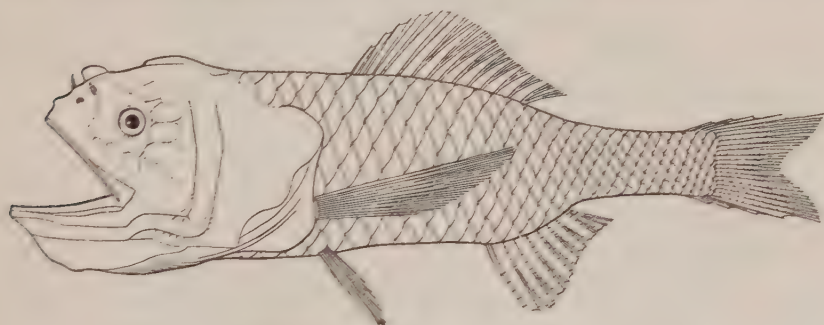


Figure 8. *Melamphaes cristiceps* Gilbert. Drawn by Y. H. Olsen.

Anal origin in the specimen on hand would seem to lie below the posterior third or fourth of the dorsal fin base, confirming the author's previous remarks concerning the unreliability of accurate definitions in regard to the relative positions of these two fins (Parr, 1931, p. 43).

***Melamphaes triceratops* Roule and Angel 1933**

Melamphaes triceratops Roule and Angel 1933, p. 66, pl. III, fig. 32.

9 specimens, No. 2811, B. O. C. Station 58, 20/4, 1927. N. 32° 24'. W. 64° 29'. 10,000 ft. wire.

1 specimen, No. 2812, B. O. C. Station 58, 20/4, 1927. N. 32° 24'. W. 64° 29'. 5,000 ft. wire.

7 specimens, No. 2813, B. O. C. Station 59, 21/4, 1927. N. 32° 19'. W. 64° 33'. 8,000 ft. wire.

The differentiation of this species from the other known species of *Melamphaes* is shown in the key on page 13. 10–11 soft rays were found in the anal fins of the various specimens, which are otherwise in perfect agreement with the description. One of the specimens, measuring 37 mm. without caudal fin, shows the following proportions in per cent of this length. Length of head 43 per cent. Diameter of eye 6.5. Length of snout 9.5. Interorbital width vertically above eyes 15.0. Least interorbital width obliquely in front of eyes 10.0. Length of maxillary 17.0. Snout to dorsal fin 49.0. Snout to anal fin 66.0. Base of dorsal fin to base of middle caudal rays 26.0. Base of anal fin to base of middle caudal rays 20.0. Dorsal fin base 22.0. Anal fin base 9.1.

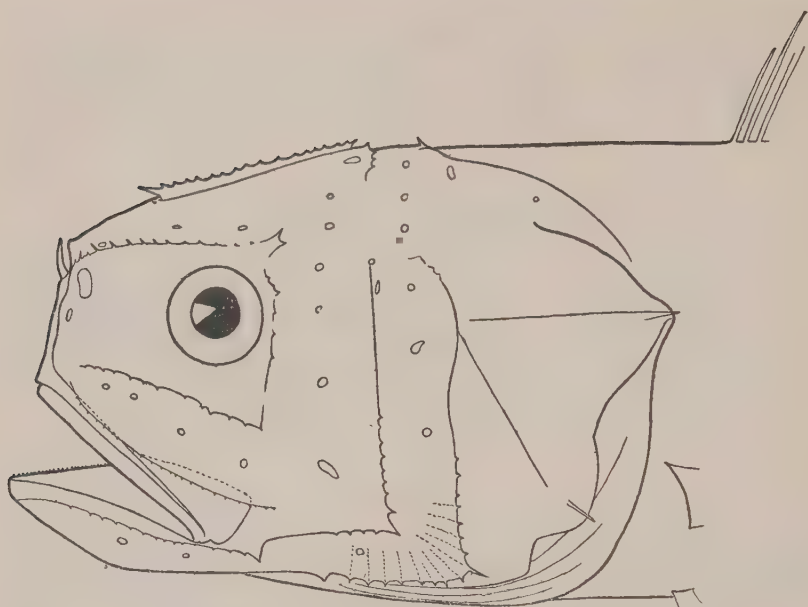


Figure 9. Head of *Melamphaes triceratops* Roule & Angel. Drawn by Y. H. Olsen.

Greatest depth of body 29.0. Least depth of caudal peduncle 9.5. Length of pectoral fins 35.0. Length of ventral fins 26.0.

***Melamphaes mizolepis* (Günther 1878)**

Melamphaes mizolepis Norman 1929, p. 168.

- 1 specimen, No. 2632, B. O. C. [large eyes], 2 specimens, No. 2631, B. O. C. [small eyes]. Station 11, March 2. N. $23^{\circ} 57' 45''$. W. $77^{\circ} 26' 25''$. 7000 feet wire.
- 5 specimens, No. 2627, B. O. C. [small eyes]. Station 16, March 9. N. $23^{\circ} 49' 15''$. W. $76^{\circ} 58' 30''$. 7000 feet wire.
- 4 specimens, No. 2630 B. O. C. [small and intermediate eyes]. Station 18, March 10. N. $23^{\circ} 42' 20''$. W. $76^{\circ} 43' 20''$. 7000 feet wire.
- 1 specimen, No. 2633, B. O. C. [large eyes], Station 23, March 14. N. $24^{\circ} 28' 35''$. W. $77^{\circ} 28' 30''$. 8000 feet wire.
- 16 specimens, No. 2634, B. O. C. [small eyes], 2 specimens, No. 2635, B. O. C. [large eyes]. Station 25, March 17. N. $24^{\circ} 51'$. W. $76^{\circ} 37' 30''$. 8000 feet wire.
- 4 specimens, No. 2637, B. O. C. [intermediate eyes]. Station 31, March 21. N. $24^{\circ} 28' 40''$. W. $75^{\circ} 53'$. 7000 feet wire.

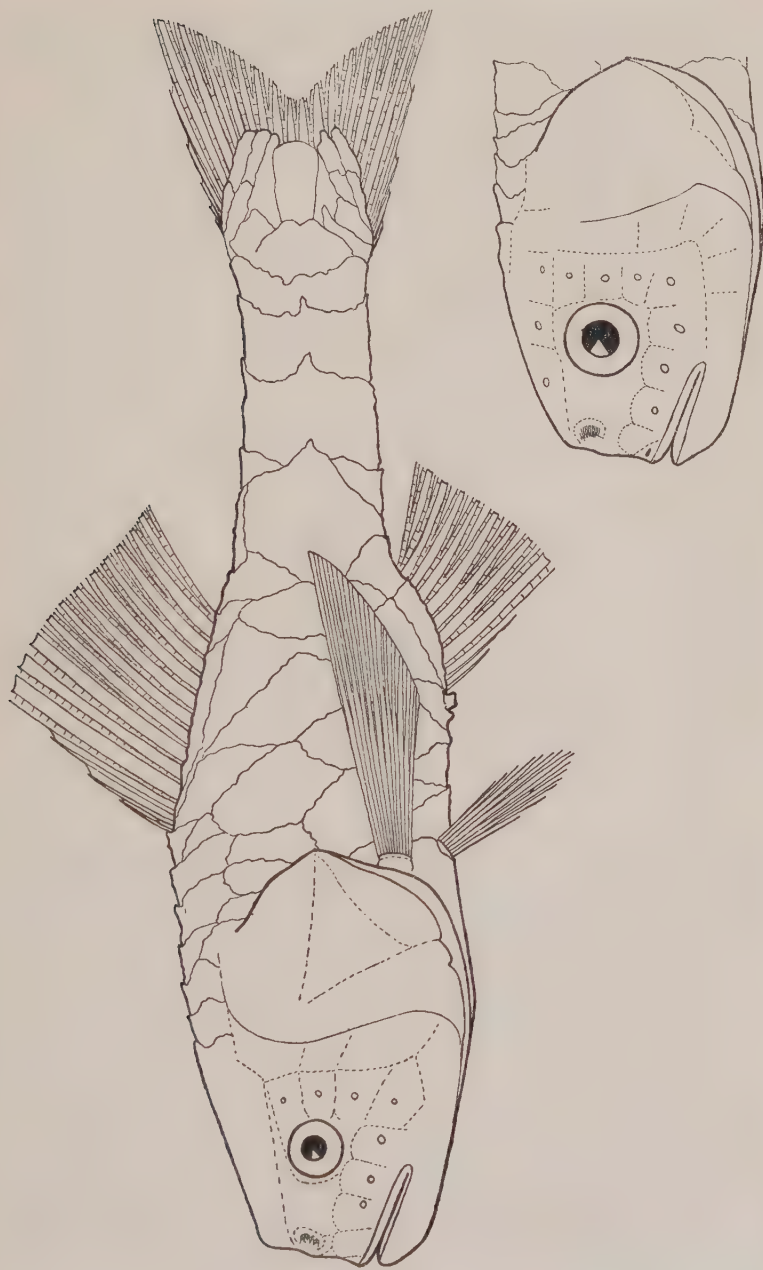


Figure 10. *Melamphaes mizolepis* (Gunther). Small-eyed specimen, above; head of large-eyed specimen, below. Drawn by Y. H. Olsen.

9 specimens, No. 2628, B. O. C. [small eyes], 5 specimens, No. 2629, B. O. C. [large eyes]. Station 39, March 29. N. $22^{\circ} 42' 33''$. W. $74^{\circ} 23'$. 8000 feet wire.

1 specimen, No. 2636, B. O. C. Station 46, April 4. N. $21^{\circ} 46' 12''$. W. $72^{\circ} 49' 30''$. 10,000 feet wire.

3 specimens, No. 2851, B. O. C. Station 48, 4/6, 1927. N. $21^{\circ} 44'$. W. $72^{\circ} 43'$. 7000 feet wire.

3 specimens, No. 2852, B. O. C. Station 52, 4/11, 1927. N. $21^{\circ} 30'$. W. $71^{\circ} 11'$. 8000 feet wire.

9 specimens, No. 2853, B. O. C. Station 56, 4/13, 1927. N. $21^{\circ} 20'$. W. $71^{\circ} 13'$. 6500 feet wire.

1 specimen, No. 2854, B. O. C. Station 58, 4/20, 1927. N. $32^{\circ} 24'$. W. $64^{\circ} 29'$. 10,000 feet wire.

As indicated by the accompanying figure, the specimens on hand show a very wide range of variations in regard to the relative size of the eyes, the

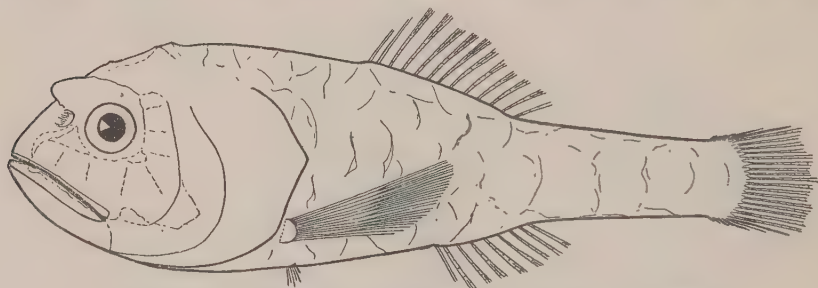


Figure 11. *Melamphaes beani* Günther. Drawn by Y. H. Olsen.

variations being such, in fact, that the author was at first inclined to believe that two distinct species were included in the material, and although intermediate proportions in some of the specimens make it quite impossible to make any sharp distinctions, it is still only with a considerable doubt that the samples are all referred to one single species only. The author is indebted to Mr. J. R. Norman for establishing by comparison with the collections in the British Museum that the large-eyed specimens are not identical with *M. beani*, which has heretofore been considered differentiable from *M. mizolepis* by this very feature, among others (see Norman, 1929, key to the species, p. 156). With the large-eyed specimens included in *M. mizolepis*, it becomes necessary to change the diagnosis of this species from "eye 6 to $7\frac{3}{4}$ " to eye 5 to $7\frac{3}{4}$ in head, making almost worthless the distinction in this respect from *M. beani* (eye $4\frac{1}{2}$ to $5\frac{1}{2}$ ¹ in head). The latter species is nevertheless easily distinguished by

¹ In the specimen received from the British Museum it does not seem possible that the eye can have been contained much less than 6 times in the length of the head (approximate estimate about $5\frac{6}{7}$ times. See the table).

characteristic differences in its general outlines and proportions as shown by figure 11, drawn for comparison, from a specimen obtained in exchange from the British Museum, through the good offices of Mr. Norman.

Measurements of *Melamphaes mizolepis* and *M. beani*

Species		<i>M. mizolepis</i>						<i>M. beani</i>
Material B. O. C. No.		2630		2627	2632	2633	2635	2695*
Length without caudal fin in mm.		75	52.5	66	56	53	46	58
Greatest depth	In per cent of length without caudal fin	28	24	26	25	25	24	31
Length of head		41	38	38	39	39	39	41
Diameter of eye		5.5	6.5	5.5	7.0	7.5	7.5	7.0†
Length of snout		11.0	9.5	10.5	11.0	9.5	8.7	10.5
Interorbital width		11.0	13.0	15.0	14.5	14.0	13.0	14.5
Length of maxillary		13.0	12.5	13.0	13.5	13.0	14.0	15.5
Length of Pectorals		32	30	30	31	31	29	23
Length of ventrals		13	16	16	15	14	15	—
Snout to dorsal		49	50	48	47	48	48	50
Snout to anal		58	58	58	59	60	59	59
Base of dorsal		20	22	21	22	21	23	22
Base of anal		11	13	13	13	11	12	13
Base of dorsal to base of middle caudal rays		35	36	33	34	32	32	31
Least depth of caudal peduncle		12.0	12.0	11.5	11.0	10.0	10.0	10.5

*Exchange specimen from the British Museum (Natural History) caught in the eastern South Atlantic (15° 55' S. 10° 35' E. 600–100 m.)

†The eye itself is too shrunken to be measurable, but the above given value (7.0 per cent) represents a (maximum) estimate of its probable size, as judged by the size of the orbit.

The measurements of various specimens of *M. mizolepis*, showing, among other features, the variations in the size of the eyes, are given in the accompanying table, together with the proportions of the above mentioned specimen of *M. beani*.

Family RONDELETIIDAE

A berycomorph family previously referred to the Iniomi (see Parr 1929). Apparently most closely related to the Melamphaidae.

Genus *Rondeletia* Goode and Bean 1895

Rondeletia bicolor Goode and Bean 1895

- 1 specimen, No. 2106, B. O. C. Station 9, 1/3, 1927. 23° 55' N. 77° 09' W. 4000–7000 feet wire.
- 1 specimen, No. 2104, B. O. C. Station 11, 2/3, 1927. 23° 58' N. 77° 26' W. 7000 feet wire.
- 1 specimen, No. 2109, B. O. C. Station 31, 21/3, 1927. 24° 29' N. 75° 53' W. 7000 feet wire.
- 2 specimens, No. 2110, B. O. C. Station 39, 29/3, 1927. 22° 43' N. 74° 23' W. 8000 feet wire.

- 2 specimens, No. 2105, B. O. C. Station 41, 30/3, 1927. 22° 31' N. 74° 26' W. 10,000 feet wire.
1 specimen, No. 2107, B. O. C. Station 48, 6/4, 1927. 21° 44' N. 72° 43' W. 7000 feet wire.
5 specimens, No. 2108, B. O. C. Station 56, 13/4, 1927. 21° 20' N. 71° 13' W. 6500 feet wire.

Order **PERCOMORPHI**

Suborder **PERCOIDEA**

Series **PERCIFORMES**

Family **CHILODIPTERIDAE**

Brinkmannella, new genus

Eyes large, snout rather long. Body covered with thin, cycloid or feebly ctenoid, rather deciduous scales of moderate size (around 35 in a longitudinal series). Cheeks and opercles scaly (condition of top of head and snout uncertain). Mouth small. Jaws equal anteriorly. Teeth in jaws small, no canines. Vomer and palatines with teeth. Posterior corner of operculum coming to a blunt, flat point supported by a slight ridge but hardly sharp enough to be described as a spine. Opercular bones (operculum, suboperculum, interoperculum, and preoperculum) otherwise smooth, without spines or serrations of any kind. Gill rakers in first arch fairly long and moderately numerous (about 11 in the lower part). Pseudobranchiae well developed. Pyloric ceca 11. Branchiostegal rays 7 (?). First dorsal with only 6 spines, widely separated from the second dorsal which has about 10-12 (11) soft rays. Anal with only one single spine and about 10 soft rays. Pectorals very long, with thin rays. Vent a very short distance in advance of anal fin. Caudal forked.

Caudal peduncle long and slender (more than three times as long as deep). Lateral line continuous. Pores simple, very large. Color dark.

Genotype *Brinkmannella elongata* n. sp.

This new genus appears to be most nearly related to *Brephostoma* Alcock, from which, however, it differs in the presence of teeth, in having 6 spines in first dorsal fin, in the character of the squamation (scales large, thick, ctenoid and adherent in *Brephostoma*), in the long snout.

The author takes great pleasure in naming this new genus after his dear teacher and friend, Prof. Dr. August Brinkmann of Bergens Museum.

Brinkmannella elongata n. sp.

- 1 specimen, No. 2837, B. O. C. TYPE. Station 22, 12/3, 1927. N. 23° 37' 25". W. 77° 15' 10". 7000 feet wire.

Length without caudal fin 32.5 mm. Proportions in per cent of length without caudal: Length of head 36. Length of snout 11. Diameter of eye 12.

Interorbital width 6.5. Length of maxillary 13. Snout to first dorsal fin 41. Snout to second dorsal 60. Snout to anal fin 61. Base of first dorsal 11. Base of second dorsal 11. Base of anal 11. Length of pectorals 34. Length of ventrals 16. Greatest depth of body 20. Least depth of caudal peduncle 8.5. Base of dorsal fin to base of middle caudal fin rays 31. Base of anal to base of middle caudal rays 31.

D.¹ VI. D.² I 11. A. I 10. P. 16. V. I 5.

Gill rakers 4/11 in first arch. Pseudobranchiae with 12 lamellae. About 35 scales in a longitudinal series on body + 4 on caudal fin. Lateral line continuous, on the third row of scales below the base of first dorsal fin. 10 rows of scales between lateral line and anal fin. Scales very thin, feebly ctenoid, with 2-7 minute points in the preserved scales from the lateral line or above, mostly cycloid in the preserved scales from below the lateral line. Most of the scales lost.

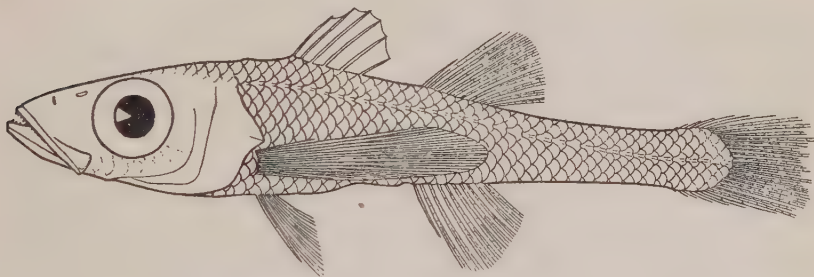


Figure 12. *Brinkmannella elongata* n. sp. Drawn by Y. H. Olsen.

Snout rather long, naked at the tip, i. e., from the nostrils forward. Skin on the top of the head lost. Maxillary barely reaching to the anterior margin of the eye. A row of probably about 7 fairly large scales occupying most of the narrow cheek below each eye, with indications that some much smaller scales may also have been present immediately along the lower margin of the orbit.

Lower jaw with an irregularly double series of small teeth partly arranged in groups. Premaxillaries and palatines each with a single series of small teeth. Vomer with 2 irregular rows of teeth across the head, arranged in a transverse crescent. Teeth small, but not as minute in proportion to the size of the jaws as in *Galeagra*, *Bathysphyraenops*, and *Erythrobussothen*.

Color uniform black.

Genus *Galeagra* Heller and Snodgrass 1903

Galeagra Heller and Snodgrass 1903, p. 193.

Rhetogramma Norman, 1930, p. 348.

Although *Galeagra pammelas* Heller and Snodgrass and *Rhetogramma sherborni* Norman seem specifically distinct from each other, the former having

only 14, the latter 22 gill rakers in the lower part of the anterior arch, etc., there can hardly be any question as to their generic identity.

In its relations to the new genus, *Bathysphyraenops*, *Galeagra* is mainly distinguished by the presence of a multifid instead of a single spine at the posterior corner of the operculum,¹ and by having only one single but sometimes bifid spine on the suboperculum.²

***Galeagra sherborni* (Norman 1930)**

1 specimen, No. 2841, B. O. C. Station 9, 1/3, 1927. N. 23° 55' 25". W. 77° 09' 10". 4000–7000 feet wire.

1 specimen, No. 2842, B. O. C. Station 23, 14/3, 1927. N. 24° 28' 35". W. 77° 28' 30". 8000 feet wire.

***Bathysphyraenops* new genus**

Moderately elongate. Eyes large. Body covered with firm ctenoid scales of moderate size (ll. 30–35). Entire head, including snout, cheeks, exposed part of maxillaries and lower jaws with scales. Jaws equal anteriorly. Pre-maxillaries moderately protractile. A single series of minute viliform teeth in each jaw. Maxillaries exposed and expanded posteriorly. No canines. Roof of mouth with several longitudinal series of minute denticles not definitely associated with the bones of the head; one series in each palatine region and five series extending backwards behind the head of the vomer. Posterior margin of preoperculum smooth except at the corner where it is armed with a short series of small spines.³ Operculum with a simple, slender spine at its posterior corner and a similar but smaller spine higher up. Suboperculum with two simple spines far apart, one at the posterior corner, one farther forward on the lower free edge, each at the end of a radiating ridge. Interoperculum with a similar spine at its posterior corner. Gill rakers long, slender, numerous, and close-set. Pseudobranchiae present. 5 pyloric coeca. 6 branchiostegal rays. First dorsal with 8 spines, well separated from the second dorsal which

¹ In both of the available specimens of *G. sherborni* there is also, as in *Bathysphyraenops* (see fig. 13) a simple, somewhat shorter spine on the upper portion of the operculum, well above the multifid spine at the posterior corner. In *G. pammelas* both the upper opercular spine and the subopercular spine is bifid, and the points of the posterior opercular spine are apparently somewhat more numerous than in *G. sherborni*.

² Unless the writer misunderstands his description, a confusion of the lower opercular bones would seem to have occurred in Norman's account of the genus *Rhctogramma*, the subopercular spine being referred to the lower part of the operculum, and the interopercular spine to the suboperculum, as shown by the illustration of *G. sherborni* (Norman, 1930, fig. 39) and by the specimens here reported upon.

³ The spines extend farther up along the posterior edge of the preoperculum in *Galeagra*.

has 9 rays. Anal with 3 spines and 7 rays. Dorsal and anal fins with single rows of scales in the interspaces between the anterior soft rays, otherwise scaleless. Caudal deeply forked. Pectorals long. Vent immediately in front of anal fin. Lateral line irregular, continuous, or interrupted; pores simple. Color dark.

Genotype *Bathysphyraenops simplex* n. sp.

The new genus is very closely related to *Galeagra* Heller and Snodgrass, from which it differs chiefly in the simple character of its posterior opercular spine, and in the presence of a second, anterior, ventral spine on the suboperculum. Both genera differ from *Parasphyraenops* Bean in the separate dorsal fins, the larger size of the scales, and the scaly snout and top of head; and from *Parahynnodus* Barnard by the presence of 3 anal spines (instead of 2 only), by the larger scales and scaly head.

***Bathysphyraenops simplex* n. sp.**

- 1 specimen, No. 2848, B. O. C. Station 22, 12/3, 1927. N. 23° 37' W. 77° 15'. 7000 feet wire.
1 specimen, No. 2849, B. O. C. Station 25, 17/3, 1927. N. 24° 51'. W. 76° 37' 30''. 8000 feet wire.
1 specimen, No. 2847, B. O. C. TYPE. Station 48, 6/4, 1927. N. 21° 44'. W. 72° 43'. 7000 feet wire.

In addition to the measurements given in the accompanying table, the following proportions in per cent of the length without caudal fin were also observed in the type specimen: Base of D¹ 12 per cent. Base of D² 11.5. Base of A 11. Longest spine in D¹ 17. Longest rays in D² and in A 17. Longest gill raker 4.5. Lower jaw 13.

D VIII + I 9. A III 7. P 14. V I 5. Gill rakers $7\frac{1}{21}$ in anterior arch. Pseudobranchial lamellae 15-16. 32-33 scales in a longitudinal series. 4 scales between origin of first dorsal fin and lateral line, 8 scales below lateral line. 13 scales in a median series from snout to dorsal fin.

In the smallest specimen the lateral line is interrupted on one side, while it descends gradually without discontinuity on the other. In the type the lateral line descends gradually and continuously on both sides, and in the third (medium-sized specimen), it is interrupted on both sides. When an interruption occurs, it is found beneath the base of second dorsal fin (farther forward in both species of *Galeagra*). Pores may be absent from several of the scales belonging to the lateral line series, without any regularity in the occurrence. The one or two most anterior lateral line pores are situated lower than the rest.

6-8 minute spines in a series at the preopercular angle. Color uniform very dark brown.

Other characters as shown in the accompanying illustration and table of measurements and in the generic diagnosis.

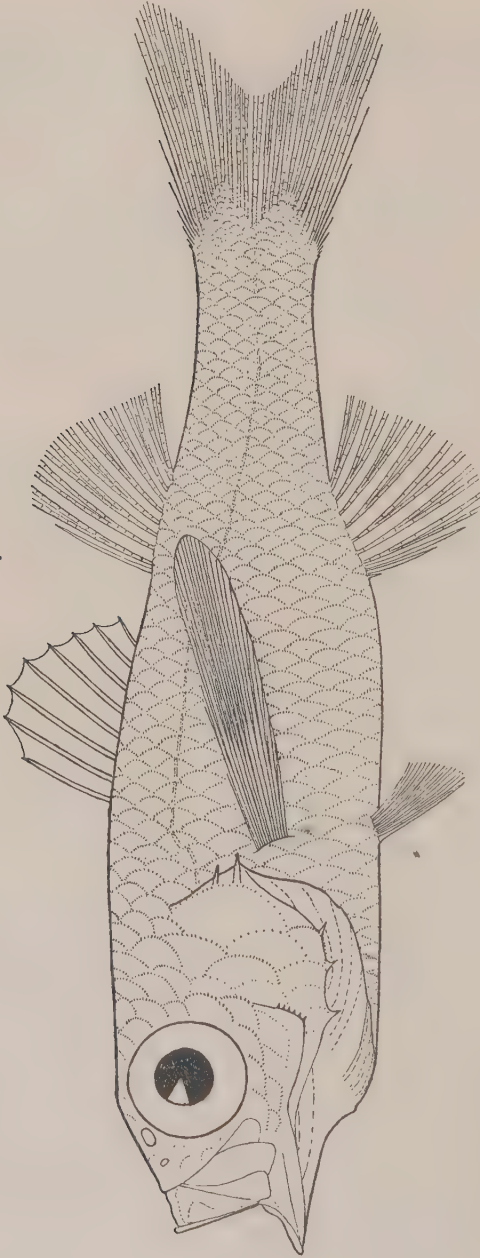


Figure 13. *Bathysphyraenops simplex* n. sp. Drawn by Y. H. Olsen.

Bathysphyraenops simplex n. sp.

Length without caudal fin in mm.	88	69	62
Proportions in per cent of length without caudal fin:			
Length of head	35	39	37
Length of snout	8.0	8.4	8.5
Diameter of eye	12	12	12
Interorbital width	8	8.5	9.0
Length of maxillary	13	13	13
Greatest depth of body	28	29	27
Least depth of caudal peduncle	12	13	12
Snout to D ¹	41	41	40
Snout to D ²	66	64	61
Snout to A	67	67	67
Length of pectorals	34	33	34
Length of ventrals	15	18	18
Length of caudal fin	28	30	27
Dorsal length of caudal peduncle (D-C)	25	25	25
Ventral length of caudal peduncle (A-C)	26	27	26

Erythrobussothen, new genus

Body slender, scarcely compressed. Eyes large. Scales moderate, ctenoid both on head and body, around 50 in a longitudinal series. Snout and frontal part of head naked; cheeks, gill covers and exposed portion of maxillaries with scales. Jaws equal anteriorly. Maxillaries exposed and expanded posteriorly. Premaxillaries moderately protractile. Each premaxillary and each limb of the lower jaw with a very small canine anteriorly, followed in the lower jaw by a single, close-set series of minute teeth and a narrow inner band of villiform dentition. A single series of minute teeth on each palatine and across the head of the vomer. Opercle with two simple flat spines. Preopercle, posterior part of interopercle and lower part of subopercle with finely serrate edges. Dorsal fins connected at the base, but distinct in their outlines. Dorsals with 10 spines and about 11 soft rays. Anal with 3 spines and 8 rays. Pectorals moderate. Caudal forked. 7 branchiostegal rays. Gill rakers long and fairly numerous. Pyloric coeca 5. Dorsal and anal entirely without scales. Vent a very short distance in advance of anal fin. Lateral line continuous. Pores simple. Color in life red.

Genotype, *Erythrobussothen gracilis* n. sp.

The new genus is apparently closest related to *Sphyraenops* Poey from which it differs, however, in having the dorsal fins connected at the base (well separated in *Sphyraenops*) in the presence of only two spines on the operculum (3 in *Sphyraenops*), in the scaleless snout, and in other features of minor importance.

Erythrobussothen gracilis n. sp.

1 specimen, No. 2840, B. O. C. TYPE. Station 5, 26/2, 1927. N. 25° 55' 50". W. 77° 37'. 5000 feet wire.

Length without caudal fin 56 mm. Proportions in per cent of length without caudal fin: Length of head 33. Length of snout 7.5. Diameter of eye 10. Interorbital width 8.2. Length of maxillary 14. Snout to dorsal fin 37. Snout to anal fin 66. Length of pectorals 19. Length of ventrals 19. Base of spinous dorsal 26. Base of soft dorsal 15. Base of anal 13.5. Length of caudal 29. Longest dorsal spine 13.5. Longest dorsal ray 10.5. Longest anal ray 11. Greatest depth of body 30. Least depth of caudal peduncle 10. Base of dorsal to base of middle caudal rays 22. Base of anal to base of middle caudal rays 22.

Snout obtuse, evenly rounded both in dorsal and lateral view. Snout and frontal part of head naked, but with numerous small pores. Pseudobranchiae with about 17–20 long lamellae.

D. X 11. A. III 8. P. 16. V I 5. About 50 scales in a longitudinal series, 6 between the origin of dorsal fin and the lateral line, 13 between lateral line and origin of anal. 7/15 gill rakers in anterior arch.

Color in life uniform bright pink. Other characters as shown by the illustration and measurements, and described in the generic diagnosis.

Family **BRAMIDAE**Genus **Brama** Schneider 1801**Brama raji** (Block 1791)

1 specimen, No. 2795, B. O. C. Station 9, 3/1, 1927. 23° 55' N. 77° 09' W. 4000–7000 feet wire.

1 specimen, No. 2796, B. O. C. Station 33, 3/22, 1927. 24° 11' N. 75° 37' W. 8000 feet wire.

The above two specimens are both quite small, measuring only 47 and 39 mm. respectively, exclusive of the caudal fin. The following counts were found: D. $35\frac{1}{2}$. A. $29\frac{1}{2}$. P. 20 in the largest specimen (No. 2795, B. O. C.); and D. $34\frac{1}{2}$. A. $27\frac{1}{2}$. P. 22 in the other. 83–85 transverse rows of scales were counted along the back above the lateral line, beginning at the top of the gill slit (thus not including the rows confined to the nape); but only 58 rows on the flanks below, in a series from the shoulder to the base of the caudal fin. Due to the fact that the transition from the smaller scales above to the larger ones below seems to take place in the lateral line series itself, it is very difficult to make any accurate count of the number of scales in the latter, and the use of the conventional lateral-line count may be apt to prove confusing in this and in the related species.

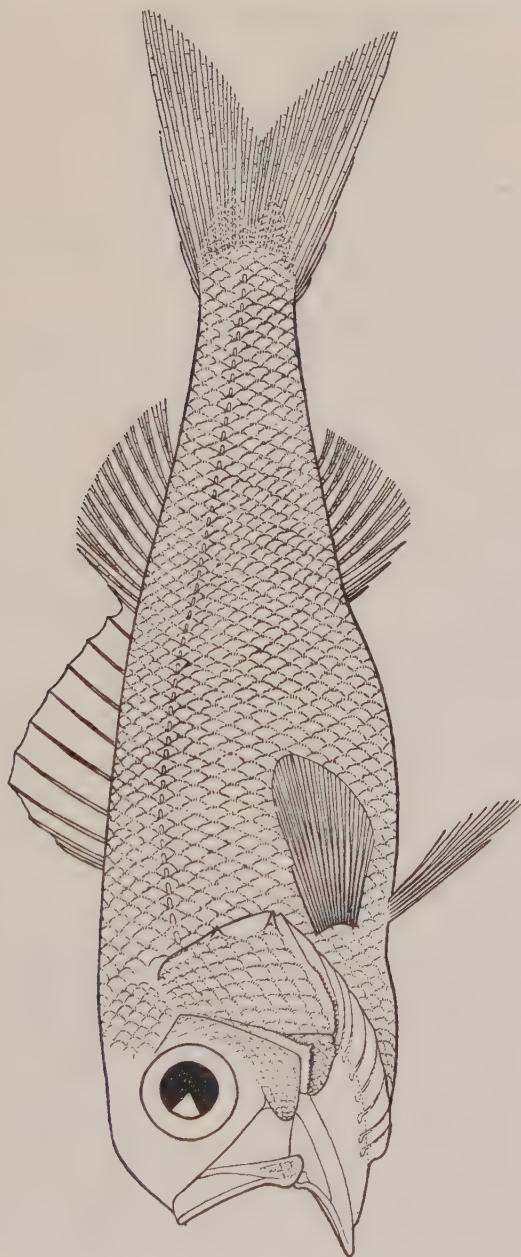


Figure 14. *Erythrobussothen gracilis* n. sp. Drawn by Y. H. Olsen.

Series *CHIASMODONTIFORMES*Family *CHIASMODONTIDAE*Genus *Chiasmodon* Johnson 1863*Chiasmodon niger* Johnson 1863

- 1 specimen, No. 2826, B. O. C. Station 58, 20/4, 1927. N. 32° 24' 15". W. 64° 29'. 10,000 feet wire.
1 specimen, No. 2825, B. O. C. Station 59, 21/4, 1927. N. 32° 19' 18". W. 64° 32' 30". 8000 feet wire.

The above two specimens collected off Bermuda both agree very well with Norman's diagnosis and description of *C. niger* (Norman, 1929a, pp. 538-39). The pectoral counts are 13 and 12 respectively (13 for the species according to Norman) and thus give added reason for segregating the Bahaman form, with six specimens showing consistently 15 pectoral fin rays, as a separate subspecies.

Chiasmodon niger pluriradiatus n. subsp.

- 3 specimens, No. 2829, B. O. C. Station 11, 2/3, 1927. N. 23° 57' 45". W. 77° 26' 25". 7000 feet wire.
2 specimens, No. 2827, B. O. C. TYPE. Station 16, 9/3, 1927. N. 23° 49'. W. 76° 58'. 7,000 feet wire.
1 specimen, No. 2828, B. O. C. Station 23, 14/3, 1927. N. 24° 29'. W. 77° 29'. 8,000 feet wire.

A new subspecies has been introduced for the reason that all of the Bahaman specimens of this species obtained during the third expedition of the Pawnee differ consistently from the general description of the species and also from the two specimens obtained at Bermuda during the same cruise, in having 15 instead of only 13 (12-13) pectoral fin rays. No other well defined distinctions are apparent to the writer, however.

The type specimen measures 49 mm. exclusive of the caudal fin. Its proportions in percent of this length follow: Length of head 28 percent. Length of snout 6.5. Interorbital width 6.0. Diameter of eye 5.0. Length of maxillary 18. Length of lower jaw 21. Greatest depth of body 16 (18-20 in other specimens). Snout to D¹ 32. Snout to D² 55. Snout to A. 55. Length of P. 21. Length of V. 12. Longest spine in D¹ 10. Longest ray in D² 14. Longest ray in A. 12. Length of Caudal fin 18. Length of caudal peduncle 13. Least depth of caudal peduncle 5.

D¹ XI (in the type, X-XII in other spec). D² 28 (26-27 in other spec). A. 29 (26-29 in other spec). P. 15 (in all specimens). V. I + 5.

Dentition and other features as in *C. niger niger*.

Genus **Dysalotus** McGilchrist 1905**Dysalotus alcocki** McGilchrist 1905

1 specimen, No. 2694 B. O. C. Station 25, March 17, 1927. 24° 15' N.
76° 37' 30" W. 8000 feet wire.

Genus **Hemicyclodon** Parr 1931

Hemicyclodon Parr, Copeia (Journ. Am. Soc. Ichth. Herpet.) 1931, No. 4, p. 162. Substitute for *Dolichodon* Parr, preoccupied.

Dolichodon Parr, Bull. Bingham Oceanogr. Coll., Vol. II, Art. 4, p. 45, 1931.

Key to the Species

I. Eyes moderate, about $6\frac{1}{2}$ in head. About 28 rays in second dorsal fin.

P. 11. *H. macrodon* Norman.

Dysalotus macrodon Norman, Ann. Mag. Nat. Hist. ser. 10, Vol. III, p. 542, fig. 10, 1929.

Dolichodon macrodon Parr, Bull. Bingham Oceanogr. Coll. Vol. II, Art. 4, p. 46, 1931.

II. Eyes very small, about 9 in head. 20–23½ rays in second dorsal fin.

A. Distance from the end of dorsal fin to the base of middle caudal rays about 9 per cent of length without caudal fin. Mouth very large, length of maxillary about two-thirds of the length of head. P. 13. D¹. XII. D² I + 23½. A. I + 24½. *H. normani* Parr.

Dolichodon normani Parr, Bull. Bingham Oceanogr. Coll. Vol. II, Art. 4, p. 46, fig. 18, 1931.

B. Free caudal peduncle longer, distance from dorsal fin to middle caudal rays equalling about 13 per cent of length without caudal fin. Mouth smaller, length of maxillary only little over half the length of head.

P. 11. D¹ X. D² I + 20½. A. I + 20½. *H. macrurus* n. sp.

Hemicyclodon macrurus n. sp.

1 specimen, No. 2739, B. O. C. TYPE. Station 41, 3/30, 1927. N. 22° 31' 15". W. 74° 26' 20". 10,000 feet wire.

Length without caudal fin 120 mm. Proportions in per cent of length without caudal fin: Length of head 23. Greatest depth 12.5. Length of snout 7.3. Diameter of eye 2.5. Interorbital width 4.6. Length of maxillary 12.5. Length of lower jaw 15. Length of longest premaxillary fang 2.1. Snout to first dorsal fin 30. Snout to second dorsal fin 53. Snout to anal fin 54. Length of free caudal peduncle from the end of second dorsal fin to the bases of the middle caudal fin rays 13. Least depth of caudal peduncle 3.5. Length of pectorals 17. Length of ventrals 16.

D¹ X. D² I + 20½. A. I + 20½. P. 11. V. I + 5. Lateral line greatly enlarged, with 35 wide pores (and sensory buds) between the top of the gill slit and the posterior end of the line, the last pore and sensory bud being

situated on the caudal fin itself beyond the bases of the fin rays. The lateral line continues without abrupt change forward to the eye, with 4-5 sensory buds anterior to the gill slit.

Each premaxillary with an outer series of about 10 very thin, strongly curved teeth and an inner series of 2-3 greatly enlarged, almost semi-circular, very slender fangs. Each palatine with about 4 teeth in a single series. Lower jaw with about 10 thin, curved teeth in the outer series and about 6 enlarged, almost semi-circular fangs in the inner row on each side. All teeth in the jaws and on palatines with a well differentiated apical portion. Vomer toothless. Gill arches with a single series of small, wide-set teeth on each. Four gills, with a small opening behind the fourth. Pseudobranchiae reduced to 2 very small filaments and one stub on each side.

Head cavernous, with wide and deep pits associated with the sensory buds of the lateral line system. Four such cavities, two on each side of a narrow median partition, occupy the dorsal surface of the posterior two-thirds of the

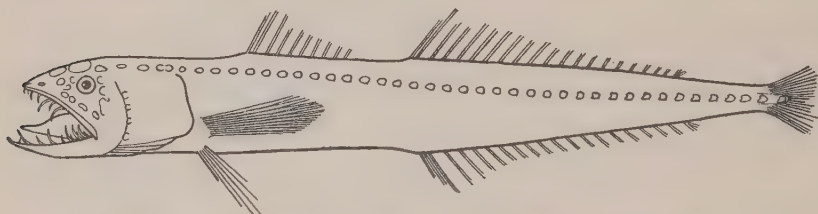


Figure 15. *Hemicyclodon macrurus* n. sp. Drawn by Y. H. Olsen.

snout, from above the centre of the eyes forward. Eight cavities in the sub-orbital series. Profiles of head and body confluent, smooth. General shape pointedly fusiform. Mouth somewhat oblique. Jaws curved, but much less so than in *H. normanni*. Maxillary extending beyond eye. Nostrils close together a short distance in advance of the orbit.

Color deep velvet brown.

The differentiation of this species from its nearest relative, *H. normanni* Parr, has been sufficiently dealt with in the key on page 35.

Genus *Pseudoscopelus* Lütken 1892

This genus is distinguished from all other Chiasmodontidae by the presence of numerous minute photophores (Beebe, 1932, p. 77: "mucous pores" of earlier authors) aggregated into definite rows of a very characteristic shape, and in the equally characteristic dentition of the greatly broadened premaxillaries and of the lower jaw. As shown in the accompanying illustration, the premaxillary dentition consists of an outer row of minute decurved, fixed teeth in a single series, with 2 or 3 minute fangs depressible caudad at the anterior

end. Inside of this outer row the anterior two-thirds of each premaxillary are greatly expanded mesad to form the basis of attachment for the inner dentition which is arranged in two groups separated from each other by an edentulous longitudinal interspace. The outer group consists of 2, the inner group of about three somewhat irregular series of long decurved fangs, depressible inward (mesad), with their curvature directed outwards (downwards in the depressed condition). In each group the length of the fangs increases inwards,

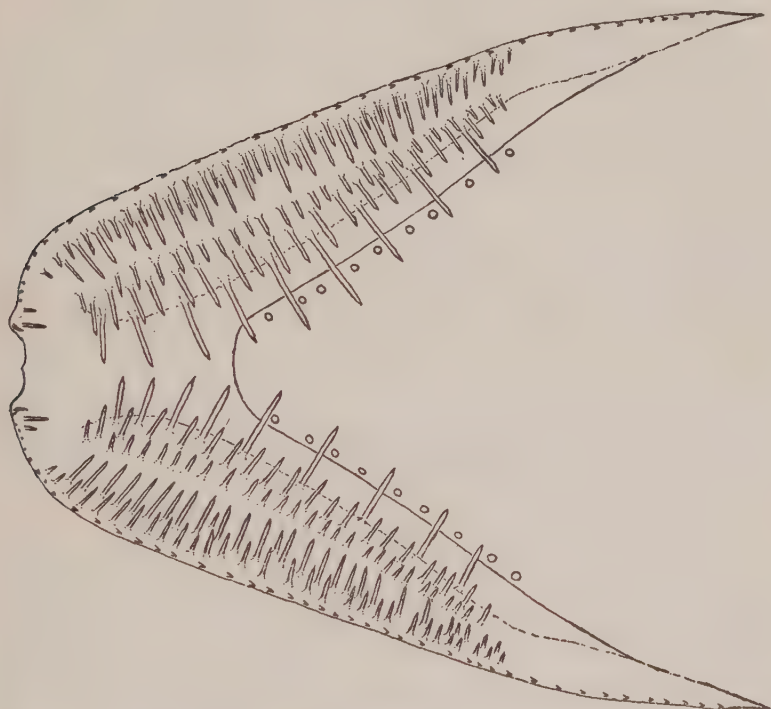


Figure 16. Ventral view of dentition in upper jaw and palatines in *Pseudoscopeelus altipinnis* n. sp. Curvature of fangs not visible in this perspective. Drawn by Y. H. Olsen.

and the fangs in the second series of the outer group are larger than those in the first series of the inner group, approximately equal to the fangs in the second series of the latter, while the innermost fangs in the inner group are much longer than any of the other teeth.

The palatines have only one single series of relatively small, erect teeth each, but due to a confusion of the inner group of premaxillary teeth with the palatine dentition, multiple series of teeth have often erroneously been ascribed to the palatines.

MEASUREMENTS AND COUNTS OF *PSEUDOSCOPELUS* SPP.

Species	Material or reference	<i>P. scriptus</i> Lütken		<i>P. sagamiensis</i>		<i>P. altipinnis</i>		<i>P. stellatus</i>
		Illus. of type ¹	2740 B. O. C.	Tanaka, 1908, p.16	Type	2800 B. O. C.	Norman ² 1929, p. 343	
	Length without caudal fin in mm.	68	58	150	120	195	90	Type
	Length of head	29.0	29.0	30.7	30.0	27.5	30.0	22
	Length of snout	6.8	7.0	7.7	7.9	8.5	8.5	32.0
	Interorbital width		8.5	9.3	9.2	9.0	7.8	8.0
	Diameter of eye	4.8	5.2	5.3	5.8	4.1	5.5	9.0
	Length of maxillary	21.0	21.0	22.7	22.5	20.8	21.0	8.0
	Length of lower jaw	23.0	24.0			22.5	22.8	21.0
	Greatest depth	21.0	20.0	20.0	17.5	18.0	23.0	23.0
	Snout to D ¹	39.0	38.0	36.7	36.5	33.0	16.7	22.0
	Snout to D ²	54.0	54.0			51.0	32.8	41.0
	Snout to A	52.0	54.0	55.4	56.6	53.0	51.0	57.0
	Length of P	23.0	23.0	28.7	29.1	18.0	52.0	58.0
	Length of V	7.8	9.5	12.0	10.4	12.0	18.0	18.0
	Length of C	21.0	20.0			21.8	12.2	11.0
	Longest spine in D ¹	8.1	9.0	10.7	10.8	10.0	20.0	21.0
	Longest ray in D ²	12.9	12.5	16.7	14.2	21.5	10.6	7-7.5
	Longest ray in A	12.9	12.5	14.0	11.8	20.5	20.0	17-18
	Length of caudal peduncle	14.0	13.0			11.5	20.0	17-18
	Least depth of caudal peduncle	6.5	5.5	7.3	6.7	6.2	10.5	8.5-9
							5.5	8.0
Lateral line pores			74-75	75	75	79-81	78-79	
D ¹		VIII	VII	VII	VII	VIII	IX	VII
D ²		22	24½	22	22	VIII	25½	26½
A		ca. 22	23½	24	22	VIII	25½	26½
P			13			VIII	25	
V			I + 5			VIII	13	

¹ Lütken, 1892, pl. 1, fig. 3.² "P. scriptus." Norman's specimen has been measured and examined by the writer.³ The upper ray, which is much shorter than the others and closely applied to the second ray, has been counted as ½ only.

In the material here reported upon, two very distinct types, or groups, can be easily recognized, being sharply differentiated from each other by the shape and anterior height of the second dorsal and the anal fins. This feature has apparently not been given any consideration in the previous literature dealing with the genus *Pseudoscopehus*, and, as a result of this, we find that Lütken's original species and genotype has undoubtedly been confused with another, entirely independent form.

The accompanying table gives the measurements and counts of the material studied by the writer, as well as the measurements obtained from Lütken's excellent illustration of *P. scriptus*. It will be seen from this table that the length of the longest rays in the dorsal fin on *P. scriptus* is only about $\frac{1}{8}$ of the total length without caudal fin, or only about $\frac{1}{3}$ longer than the longest spine in first dorsal; while the length of the longest ray in the second dorsal in *P. altipinnis* n. sp. is more than $\frac{1}{8}$ of the total length without caudal fin, or nearly twice the length of the longest spine in first dorsal. The fact that this distinction is equally clear whether we compare our medium-sized specimen of *P. scriptus* with the much larger type specimen of *P. altipinnis*, or with the much smaller paratype of the latter, precludes the possibility that the difference between the two forms might be entirely due to, or even in any manner correlated with, differences in size and age, only, and thereby proves the existence of at least two entirely distinct species.

It seems most probable (see key) that *P. altipinnis* is also entirely separate from *P. stellatus* Beebe, and *P. sagamiensis* Tanaka may also have a legitimate claim at least to a subspecific distinction based upon the features shown in the accompanying table of counts and proportions and in the following key:

Key to the Genus *Pseudoscopehus*

- I. Longest rays in second dorsal and anal fins less than $1\frac{2}{3}$ as long as longest spine in first dorsal. Pectorals more than twice as long as ventrals. A transverse group or band of "pores" (luminous organs) immediately behind the ventral fins. *P. scriptus* Lütken.
 - A. Longest rays in second dorsal and anal fins only about $\frac{1}{8}$ of total length without caudal, and less than $1\frac{1}{2}$ times the length of the longest spine in first dorsal. *P. scriptus scriptus* Lütken.
 - B. Longest rays in second dorsal and anal fins about $1/7$ or more of the total length without caudal, and about $1\frac{1}{2}$ times the length of the longest spine in first dorsal fin. Length of ventral fins more than one-tenth of length without caudal¹. . . . *P. scriptus sagamiensis* Tanaka.

¹ To this could perhaps also be added that the length of the pectorals in *P. s. sagamiensis* is more than one-fourth of the total length without caudal, while they are less than one-fourth of this measurement in *P. s. scriptus* (see table). This difference, however, may be due only to the difference in size between the specimens

- II. Longest rays in second dorsal and anal fins about twice the length of the longest spine in first dorsal, and more than $\frac{1}{2}$ of the total length without caudal fin. Pectorals $1\frac{1}{2}$ -2 times as long as the ventrals, and about $\frac{1}{4}$ of the length without caudal. A transverse group or band of "pores" (luminous organs) immediately behind the ventrals. Origin of second dorsal midway between snout and base of caudal. *P. altipinnis* n. sp.
- III. Longest rays in second dorsal and anal fins twice as long as the longest spine in first dorsal, or longer, but less than $\frac{1}{2}$ of the total length without caudal. Pectorals about $1\frac{1}{2}$ times the length of the ventrals. No transverse group or band of luminous organs immediately behind the ventrals. Origin of second dorsal fin distinctly closer to the base of caudal fin than to the snout¹. *P. stellatus* Beebe.

***Pseudoscopelus scriptus* Lütken 1892**

Pseudoscopelus scriptus Lütken 1892, p. 284, pl. I, figs. 3-5. Goode and Bean 1896, p. 292, fig. 266. *Nec* Norman 1929, p. 543, fig. 11.

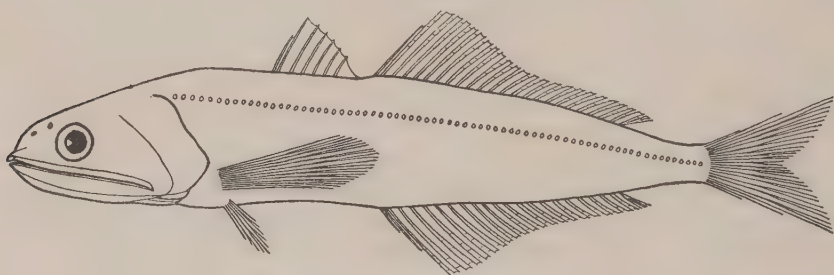


Figure 17. *Pseudoscopelus scriptus* Lütken. Drawn by Y. H. Olsen.

1 specimen, No. 2740, B. O. C. Station 48, 4/6, 1927. N. $21^{\circ} 44'$. W. $72^{\circ} 43' 25''$. 7000 feet wire.

compared, as indicated by the relationship in this respect between the type and paratype of *P. altipinnis*. In the case of the dorsal, anal and ventral fins, on the other hand, we have no such indications of a change in proportions with growth in any part of our material of the genus *Pseudoscopelus*, the identical measurements obtained from the two specimens of *P. altipinnis*, on the contrary, tending to prove a very high degree of constancy in these features. This might, of course, be purely accidental, and the distinction between *P. s. scriptus* and *P. s. sagamiensis* may ultimately prove invalid, but at the present time it seems advisable to retain also the latter designation with a subspecific rank.

¹ The author has not yet deemed it advisable to use the relatively large size of the eyes in *P. stellatus* as a key character for its differentiation from the other species of *Pseudoscopelus*, as the feature in question may quite probably prove to be largely due to the small size of the type material of Beebe's species. The same may, of course, also hold good for some of the other characters mentioned in the above key.

The general appearance of the species is indicated in the accompanying figure 17, and the counts and measurements have already been given in the table on page 38.

***Pseudoscopelus altipinnis* n. sp.**

Pseudoscopelus scriptus Norman 1929, p. 543, fig. 11; *Nec* Lütken 1892.

1 specimen, No. 2798, B. O. C. TYPE. Station 25, 3/17, 1927. 24° 51' N. 76° 28' W. 8000 feet wire.

1 specimen, No. 2800, B. O. C. Station 48, 4/6, 1927. 21° 44' N. 72° 43' W. 7000 feet wire.

The proportions and counts of this new species have already been dealt with in detail in the table on page 38, and its general appearance is well brought out in the accompanying figure 18, which should be compared with figure of *P. scriptus* to show the characteristic difference in the outlines of the vertical fins in these two forms.

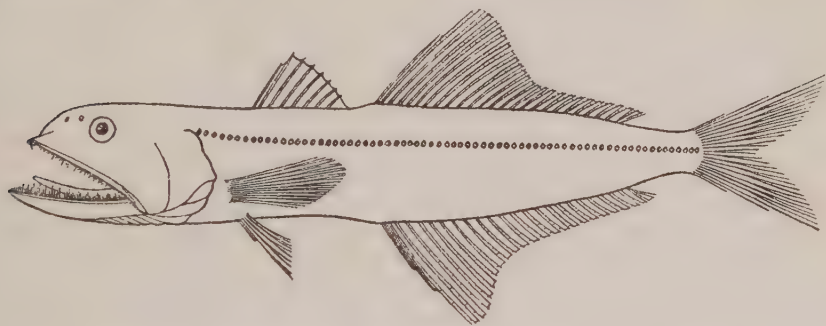


Figure 18. *Pseudoscopelus altipinnis* n. sp. Drawn by Y. H. Olsen.

Snout bluntly rounded. Body slender, its depth less than one-fifth of the length without caudal. Caudal deeply forked. Longest rays in second dorsal and anal about one-fifth of the total length without caudal, or more.

All the characteristic rows of minute photophores are present (see Lütken, 1892, pl. I, figs. 3-4): the maxillar, the mandibular, the jugular median, the thoracic median, the pectoral axial with extension along lower pectoral ray, the ventral axial and transverse, the abdominal median, and the anal on each side above the base of anal fin. Apart from the most anterior portion of the jugular, the ventral median rows (jugular, thoracic and abdominal) all consist of two longitudinal series of photophores placed close together, with a tendency for them to be arranged in transverse pairs, although this paired arrangement does not obtain throughout. The following counts were made on the smallest of the specimens: Jugular 3×1 (single organs) + 8 - 9×2 (two longitudinal series, partly paired). Thoracic about 13×2 . Abdominal $22 - 23 \times 2$. The anal series on each side contained about 90-95 organs. The ventral axillary patch

and transverse row 8-9. The row along the lower pectoral finray counted forward to the anterior end of the pectoral axillary patch 20-22, in addition to which there were 6-8 organs above this row in the axillary patch. The mandibular and maxillar (the posterior portion of the maxillar would correspond to the preopercular of Beebe, 1932, p. 77) are both present in the form of long rows, not oval groups as in *P. stellatus*. The mandibular patch starts with a triangular expansion at the preopercular corner and extends to below the middle of the eye. The mandibular patch also extends to the middle of the eye but reaches only about halfway to the preopercular corner posteriorly. There is also a small anterior mandibular patch behind the second lateral line pore in the mandibular series. Caudal series $5 \times 1 + 8 - 9 \times 2$.

Each premaxillary with an outer series of about 35-40 small, decurved fixed teeth extending the entire length of the jaw and with three teeth at their anterior end, which are depressible backwards, the anterior and the lateral one of these three teeth being small, the inner, posterior one a larger, moderate fang. Beginning about one-eighth the premaxillary length behind the anterior end of this bone it has a lanceolate, tooth-bearing expansion which occupies about six-tenths of its length and which carries at least five (5+) rows of long slender teeth, depressible inwards, inside of the outer row of small fixed teeth. These inner, depressible teeth form two distinct groups, an outer, consisting of the first and second rows (1-2+) and an inner group of the third to fifth rows. The two groups are separated by a well marked interspace¹ and the teeth in the inner series of each group are longer than the other teeth of the same group, those in the inner series of the outer group being also longer than those in the outer series of the inner group, approximately equal to those in the second series of the latter, while those in the inner series of the inner group are much longer than any of the others (apparently also proportionately considerably longer than they are in *P. scriptus*). The innermost series of fangs contains about 9-11 teeth. Each limb of the lower jaw also has about 5 series of slender teeth increasing in size inwards. Palatines each with a single row of Teeth. Gill arches with teeth.

The fin counts are given in the table on page 38. Color uniform black.

Suborder BLENNIOIDEA

Family BROTLIDAE

Genus *Barathrodemus* Goode and Bean 1883

With the new form described in the following three species in all have been referred to the genus *Barathrodemus* and can be differentiated from each other as follows:

¹ There is some possibility that this interspace may have caused the inner group to be counted by superficial inspection as palatine dentition and thus may have caused some confusion in regard to the numbers of premaxillary and palatine rows of teeth. It is believed by the author that the arrangement here described will prove characteristic of the entire genus *Pseudoscopelus*, as it is characteristic of both of the two species now at hand (*P. scriptus* and *P. altipinnis*).



Figure 19. Above: *Barathrodemus microps* n. sp. Below, *Brachylaena nigra* n. sp. Drawn by Y. H. Olsen.

B. manatinus Goode and Bean. Eye 5 in head. Snout slightly longer than the horizontal diameter of the eye. Head about 6; depth of body $7\frac{1}{2}$ in length without caudal.

B. nasutus Radcliffe (1913, p. 152, p. 10, fig. 2). Eye 6.4 in head; 1.6 in snout. Head 4.78; depth of body 4.25 in length without caudal.

B. microps n. sp. Eye 8 in head; 2.2 in snout. Head 5; depth of body 6 in length without caudal.

***Barathrodemus microps* n. sp.**

1 specimen, No. 2850, B. O. C. Station 20, 3/11, 1927. N. $23^{\circ} 54' 10''$. W. $77^{\circ} 09'$. 8000 feet wire.

Length without caudal fin 136 mm. Proportions in per cent of length without caudal: Length of head 20. Length of tumid snout 5.5. Diameter of eye 2.5. Length of maxillary 7.7. Interorbital width (soft) 6.6. Length of pectorals 14.5. Length of ventrals 8.8. Length of caudal 11.5. Snout to anal fin 37. Greatest depth of body 16.5.

D 98-102. A 86-87. P 22. V 2. C 8, 6 branched. About 45 scales in an oblique series upward and forward from the origin of anal fin to the base of dorsal. Probably around 140 scales from the gill opening to the base of caudal fin.

Four stubby + 13 long gill rakers in lower part of anterior arch. 1 long gill raker + 4 stubby ones in upper part. Although the stubby gill rakers are very well developed and the long rakers are somewhat graduated below (hardly at all above), the distinction between stubby and long rakers is nevertheless very sharp and conspicuous both as regards their length and their shape.

Snout tumid, very prominent. Anterior end of maxillary approximately midway between tip of snout and anterior margin of eye. Posterior end of maxillary well behind eye. Eyes small, less than half the length of the tumid snout. Soft interorbital space somewhat wider than the length of the snout. Head 5 in length without caudal, all parts swollen, tumid, and completely scaled. Greatest depth of body about 6 in length without caudal. Ventrals bifid, inserted immediately behind humeral symphysis.

Villiform teeth in bands on jaws and palatines, and in a broad triangular patch on the vomer.

Color uniform dark, purplish brown.

Genus *Neobythites* Goode and Bean 1885

***Neobythites phyllosoma*, n. sp.**

1 specimen, No. 2902, B. O. C. TYPE. Station 52, 11/4, 1927. $21^{\circ} 30' N$. $71^{\circ} 11' W$. 8000 feet wire.

Length without caudal fin 100.5 mm. Proportions in per cent of length without caudal fin: Greatest depth of body 28. Length of head 22.5. Length of

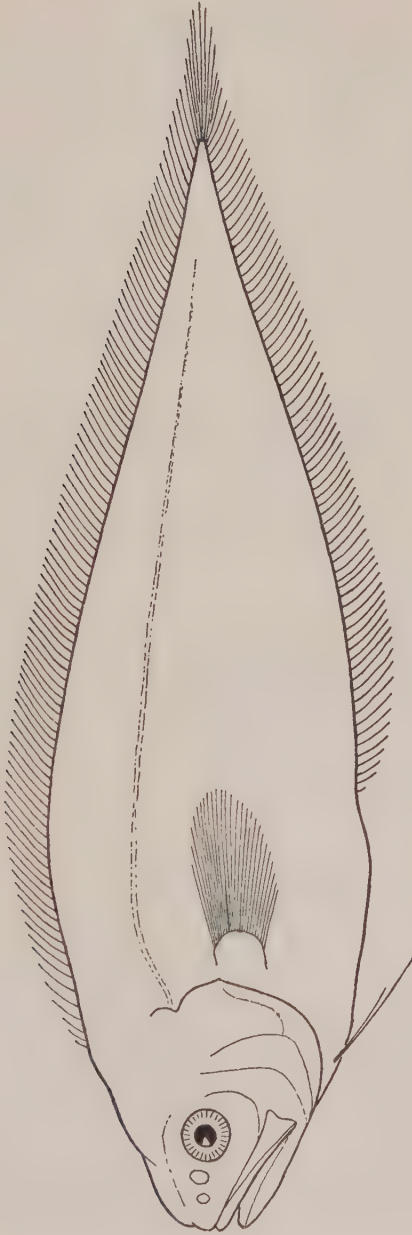


Figure 20. *Neobythites phyllosoma* n. sp. Drawn by Y. H. Olsen.

snout 6.5. Diameter of eye 4.5. Interorbital width 8.0. Length of maxillary 11.3. Snout to anal fin 42.0. Snout to dorsal fin 19.0. End of lateral line to base of caudal fin 11.0. Length of caudal fin 13.0. Length of pectorals 16.5. Length of ventrals 12.5.

D. 97. A. 71. C. 10. P. 26. V. 2. About 155 scales in a longitudinal series from gill opening to base of caudal fin. 21 scales between lateral line and dorsal fin. Lateral line distinct and continuous backwards to about the 130-135 transverse row of scales, where it ends, about 11 per cent of the length without caudal removed from the base of caudal fin. Only 4 developed gill rakers in the first arch, at the angle and below (all to be counted as belonging to the lower part). Upper part of the arch with tubercles, lower part below the 4 gill rakers practically smooth. 21 finger-like pyloric coeca, at the pylorus and immediately adjacent part of the gut. Pseudobranchiae very small, consisting of 6 minute lamellae each.

Body very deep and strongly compressed, semitransparent in its caudal and dorsal parts, its leaf-like appearance accentuated by the rather wide, entirely confluent vertical fins. Skin very loose. Head and body completely covered with scales. Fins without scales. Ventrals inserted immediately behind humeral symphysis. Ventral rays united by fin membrane for the greater part of their length, but free at the tip.

Villiform teeth in bands in the jaws and palatines and in a $\sim$ shaped band on the vomer. Preopercle with a minute spine at the angle, and a still smaller spine farther up; both under the skin. Opercle with a fairly strong but completely hidden spine, requiring removal of the skin to become visible. Maxillary reaching to immediately behind the posterior margin of the orbit.

Distinct from all other species of *Neobythites* by its great depth of body (3.75 in length without caudal) but perfectly concordant with the generic diagnosis (see Radcliffe 1913, p. 138) in all other features.

Genus *Barathrites* Zugmayer 1911

Barathrites iris Zugmayer 1911

Barathrites iris Zugmayer 1911a, p. 11; 1911b, p. 132, pl. VI, fig. 3.

1 specimen, No. 2736, B. O. C. Station 54, 4/12, 1927. N. $21^{\circ} 15' 40''$. W. $70^{\circ} 17' 06''$. 7500 feet wire. 900-955 fathoms depth. Bottom haul.

While in most other respects quite concordant with Zugmayer's description of the type, the specimen now at hand differs by having only 150-155 scales in a longitudinal series between shoulder and base of caudal fin, as compared with a count of about 200 recorded by Zugmayer, the transverse scale counts, on the other hand, being the same on both. It will also appear from the following measurements that the eyes of the specimen at hand seem to be somewhat larger and the interorbital space narrower than in Zugmayer's specimen, while

the fin counts and most of the other proportions are identical in the two, as are also their total lengths.

Total length without caudal fin 233 mm. (230 Zugm.). Proportions in per cent of the total length without caudal fin: Length of head 16.1 (15.2 Zugm.). Depth of head 10.5 (10.5 Zugm.). Greatest depth of body 18.9 (17.5 Zugm.). Height of body above origin of anal fin 17.6. Length of snout 4.1 (3.5 Zugm.). Diameter of eye 2.3 (1.7 Zugm.). Interorbital width 4.1 (5.2 Zugm.). Length of maxillary 6.4. Length of lower jaw 7.5. Snout to anus 43 (43.5 Zugm.). Snout to anal fin 47. Snout to dorsal 21.2. Length of pectoral 8.4. Length of ventrals 7.1.

D. 112-115. A. 85.

Genus **Parabrotula** Zugmayer 1911

Parabrotula dentiens Zugmayer 1911

1 adult and 11 juvenile specimens, No. 2856, B. O. C. Station 18, 3/10, 1927. N. 23° 42' 20". W. 76° 43' 20". 7000 feet wire.

Length without caudal fin 41 mm. Proportions in per cent of length without caudal fin: Length of head 15. Greatest depth of body 13.5. Length of snout 3.5. Diameter of eye 3. Length of maxillary 6. Length of lower jaw 9.5.



Figure 21. Newly born young of *Parabrotula dentiens* Zugmayer. Drawn by Y. H. Olsen.

Interorbital width 2.2. Length of pectorals 7.5. Distance from origin of dorsal to base of caudal fin 50. Distance from origin of anal to base of caudal fin 45.

D. 38. A. 35. C. 6. P. 7.

Lower jaw deep, prominent, with a single series of minute teeth. Maxillary barely reaching below middle of eyes.

Only two species have heretofore been referred to the genus *Parabrotula*, viz., *P. plagiophthalmus* Zugmayer and *P. dentiens* Beebe (1932, p. 81, figs. 19 and

20), the former with the maxillaries only extending to below the middle of the eyes, while in the latter they extend beyond the posterior margin of the orbit. In this respect the specimen here reported upon agrees perfectly with *P. plagio-phthalmus*; it differs, however, in the presence of teeth in lower jaw and in the dorsal and anal fin counts. In regard to the former character, Zugmayer (1911, p. 130) has already expressed the opinion that the lack of dentition in his very small specimen (total length only 24 mm.) may be merely a juvenile feature, and with the expressions: "*D. env.*¹ 40; *A. env.*¹ 30" that author also gives indication of some uncertainty as to the actual fin counts of his specimen. In view of these facts, the present writer has not felt justified in making any definite taxonomic distinction between Zugmayer's species and the specimen on hand. Although the differences in the dorsal or in the anal fin counts compared separately do not seem very important, the fact that Zugmayer's counts would indicate the presence of 10 more rays in the dorsal than in the anal fin, while in the specimen on hand there are only 3 more dorsal than anal rays, would probably be significant of taxonomic distinctness, if Zugmayer's approximate figures should be verified on better material.

The specimen here reported upon is a female which gave birth to living young immediately after capture. One of these young, 6.5 mm. long, is shown in the accompanying figure 21.

Brotulotaenia new genus

Body very elongate, strongly compressed, ribbon-like; with microscopic,² polygonal, non-imbricating, strongly adherent scales of a characteristic, concave, dish-like shape, with their pointed corners bent outward. A similar squamation is also found on most parts of the head, the scales, however, becoming so very minute towards the snout that they are very difficult to make out even under a binocular microscope, although they seem to be present also on the most anterior parts before the eyes. Head small (about 10 in length), somewhat less strongly compressed than the body, not tumid. Skull without crests. Parietals separated by supraoccipital. Snout not projecting beyond mouth. Mouth moderately oblique. Maxillary expanded posteriorly. Lower jaw included when the mouth is closed. Very small, slender, decurved teeth in a single series in each jaw and on the palatines. Similar teeth in a **Λ**-shaped series, with a few teeth behind it, on vomer. No fangs. Eyes large, lateral, rather high. Opercle thickened, with a broad horizontal and a similar vertical ridge, but without spines. Other opercular bones also unarmed. Gill openings very wide. Gills 4, an opening behind the fourth. Pseudobranchiae present. Gill membranes united anteriorly, free from isthmus. Gill rakers only represented

¹ Italics here.

² Diameter 0.2-0.3 mm., or less.

by minute transverse rows of spines. Pyloric coeca 5. No lateral line on body. Lateral line pores on head opening through minute papillae. Vent at origin of anal fin. Ventral fins absent. Pectorals moderate; with numerous (more than 20) rays. Vertical fins confluent, with the distal part of all their rays free from the fin membrane. Caudal narrow, not conspicuously extended. Dorsal and anal fins somewhat elevated at a short distance in advance of the end of the tail so as to give an arrow-point outline to the caudal part of the vertical fins. Dorsal origin above gill openings.

This new genus is apparently closely related to *Lycodapus* Gilbert (1890, p. 108) and to *Snyderia* Gilbert (1905, p. 654). It differs from *Lycodapus*, however in the presence of pseudobranchiae, in having 7 instead of only 6 branchiostegal rays, in the smaller size of the head, and different shape of snout and mouth (less oblique); and from *Snyderia* by the absence of enlarged fangs, the

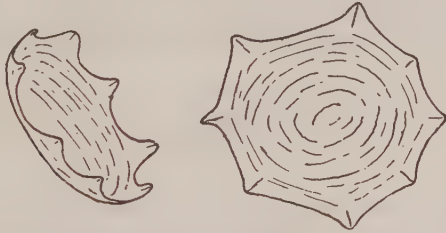


Figure 22. Enlarged scales of *Brotulotaenia nigra*, in two views. Drawn by Y. H. Olsen.

presence of 5 pyloric coeca (instead of only 2), the much longer trunk,¹ and in the different shape of the head.

Genotype, *Brotulotaenia nigra* n. sp.

Both *Lycodapus* and *Snyderia* are defined as being scaleless, but the striking similarity between the appearance of the "small quadrate or roundish pigment spots" in Gilbert's illustration of *Snyderia canina* (Gilbert 1905, pl. 92) and the appearance of the peculiar squamation in *Brotulotaenia* makes the writer feel strongly inclined to suspect that a closer examination may reveal the presence of similar minute scales also in *Snyderia*, and this is not unlikely to be true of *Lycodapus* as well. It should be kept in mind that this squamation is such that its discovery without modern optical equipment would be rather unlikely, especially since the scales are so strongly adherent that they are not easily scraped off or even pried off with a needle. For this reason the author does not consider it advisable to use the feature of its scaliness to differentiate *Brotulotaenia* from *Lycodapus* and *Snyderia*.

¹ Distance from snout to anal fin in *Snyderia canina* 5.8 in total length; less than 4 in *Brotulotaenia nigra*.

Brotulotaenia nigra n. sp.

1 specimen, No. 2855, B. O. C. Station 52, 4/11. N. 21° 30'. W. 71° 11' 04''. 8000 feet wire.

Length without caudal fin 286 mm. Proportions in per cent of length without caudal fin: Greatest depth of body 5.9. Length of head 9.5. Length of snout 2.36. Diameter of eye 2.15. Interorbital width 2.54. Length of maxillary 5.1. Snout to vent 25.5. Length of pectorals 2.6.

D. 118-120. A. 98-100. P. 24. C. 5, counting only the rays which show a slightly increased thickness and length as compared with the neighboring dorsal and anal rays.

Dorsal profile of head almost straight. Maxillary reaching to vertical from posterior margin of eye. No normal gill rakers but about 4/10 transverse rows of spines on the anterior gill arch. Pseudobranchiae with 4 small, branched filaments. Entire exterior, inner lining of mouth and gill cavity, peritoneum and even the outer mesenteries deep black.

Other characters as described in the generic diagnosis and shown in figure 19, page 43.

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CONCLUDING REPORT ON FISHES

WITH SPECIES INDEX FOR ARTICLES 1-7 (FISHES OF THE THIRD
OCEANOGRAPHIC EXPEDITION OF THE "PAWNEE")

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The present report concludes the account of the fishes obtained during the third expedition of the "Pawnee" in 1927, under the leadership of Harry Payne Bingham. A few groups in which the collections do not contain sufficient material for comparison to secure reliable identifications, and various samples of juvenile or larval forms have been entirely omitted from these reports and reserved for future investigation. Adult material thus set aside includes only the genera *Psenes*, *Cubiceps*, *Ariomma* and related forms.¹ Among larval and juvenile specimens omitted from these records are chiefly the Leptocephali and miscellaneous shallow-water teleost larvae. Two juveniles suggesting relationship to the little-known genus *Notosudis* Waite (*Iniomi*) are of particular interest, but too small to warrant any published discussion at the present time.

An index to the species reported in the preceding articles of this volume is included at the end with a few addenda and corrections.

ELASMOBRANCHI

Isistius brasiliensis Quoy and Gaimard

1 specimen, No. 3727 B. O. C. Station 18, 3/10, 1927. 23° 42' N. 76° 43' W. 7000 ft. wire. 422 mm. total length (including caudal fin).

TELEOSTEI

Order **ISOSPONDYLI**

Family **ALEPOCEPHALIDAE**

Two fairly recent keys to the genera of this family are now available (Norman, 1930, p. 267, and Beebe, 1933, p. 15), but neither one has proved very satisfactory for the identification of the five genera and seven species present in the material here reported upon. The main difficulties arise from the following

¹ Although a considerable collection is actually available, it has proved impossible to clear up the complicated specific and generic relationship in this group until still more material has been accumulated.

facts: (1) the scales may be quite firm and with very conspicuous pockets in one species while they are extremely deciduous with hardly perceptible pockets in a closely related form; and (2) that a mid-dorsal dermal finfold in advance of the dorsal fin may be present in all intergradations of development also in species not belonging to the genera for which this feature has been used as a diagnostic character.

On the other hand, far too little attention would seem to have been given to the systematic value of many other features of apparently generic significance. The difficult groups are those centering around the genera *Alepocephalus* (*Alepocephalus*, *Conocara*, *Ericara*?, *Xenognathus*, *Halisauriceps*, *Normania* n. gen. and *Whitleydia*) and *Bathytroctes* (*Bathytroctes*, *Bajacalifornia*, *Talismania*, *Holthyrnia* n. gen., *Searsia* n. gen., *Nemabathytroctes*, *Binghamia* n. gen., et al.). In each of these two groups it seems indicated, from the unfortunately very incomplete records, that variations in number of pyloric coeca, height of gill opening (which seems correlated with size of gill membrane), number of scales, relative positions of vertical fins and vertical fin-ray counts, considered separately or in correlation with each other, may provide very clear distinctions between generic groups of species. Further distinctions can in special cases be easily made on the basis of luminous organs and particular features of dentition. That generic distinctions beyond those currently recognized are warranted and desirable will be obvious to anybody who has had opportunity to compare, for instance, the strikingly dissimilar typical species of *Alepocephalus* and *Conocara*. This feeling has also found implicit expression in Fowler's introduction of several new genera and subgenera of Alepocephalid species. Although the available material is, of course, inadequate for a complete revision of the family, the writer will therefore nevertheless venture to make the following suggestions for a reorientation of the general classification of the species into groups of generic rank.

TENTATIVE SYNOPSIS OF THE GENERA OF THE ALEPOCEPHALIDAE

- I. Ventrals about the middle of the length without caudal fin, or entirely absent. Mouth and jaws large or small, but always normally proportioned and developed. Eyes normal.
 - A. Snout produced, tubular, more than twice the length of the mouth, which is small but normal. Anal fin much longer than, and originating far in advance of, dorsal fin. Ventrals present.

Aulostomatomorpha Alcock 1890.
 - B. Snout normal, less than twice the length of the mouth, which may be small or large.
 - 1. Cleithra with a pair of coalescent extensions from their ventral symphysis projecting forward as a long free spine. Body very deep, height about $\frac{1}{3}$ or more of length (in adults, over 100 mm., not valid for young specimens). Body entirely scaled. Dorsal

and anal fins posterior, equal and opposite. Head 3 or more in length without caudal.

a. Ventral fins absent. Scales keeled.

Platytroctes Günther 1878.

b. Ventral fins present. Scales without keels.

Platytroctegen Lloyd 1909.

2. Ventrals always present. Cleithral projection small or absent. Depth of body much less than $\frac{1}{3}$ of length without caudal.

a. Vertical fins posterior, relatively long and low, the distance from the end of dorsal fin to the base of the middle caudal rays always less than half the length of dorsal fin-base. Skin naked, usually thick, tough and nodulated. Head small, less than 30 per cent of length without caudal. Snout short and blunt. Mouth small. Eyes very large.¹ Maxillaries toothless or with only few teeth. Vertical fins equal or anal longer than dorsal.

x. Vertical fins very long. Anal (ab. 70) much longer than dorsal (ab. 45-50) and beginning far in advance. Free caudal peduncle contained more than 15 times in dorsal fin-base. Head small, about 5 in length. Body elongate, greatest depth more than 12 in length.

Leptoderma Vaillant 1888.

xx. Vertical fins moderately long, about equal and opposite. Distance from dorsal fin to base of middle caudal rays less than 5 times in dorsal fin-base. Head about $3\frac{1}{2}$ to $4\frac{1}{2}$ in length. Depth less than 6 in length.

o. Dorsal and anal with 15-21 rays.

Rouleina Jordan 1923.

oo. Dorsal and anal with 27-30 rays.

Xenodermichthys Günther 1878.

b. Skin naked, nodulated, thick. Vertical fins posterior moderate or short, about equal and opposite. Head moderate or small, $3\frac{1}{2}$ -6 in length without caudal. Snout short, mouth small.

x. Head moderate, less than 4 in length without caudal.

Rouleina Jordan 1923.²

¹ This group could probably be included in group *dx* (premaxillaries forming major portion of upper margin of mouth) within which it could then be differentiated by the above characters.

² Fowler (1933, p. 256) has introduced a new subgenus of *Rouleina* under the name of *Bathypnopteron*, with the following definition: "Anal origin little behind dorsal origin. Maxillary reaches beyond eye center to hind eye edge or slightly beyond." Genotype *Aleposomus nudus* Brauer.

xx. Head very small, about 6 in length without caudal.

Photostylus Beebe 1933.

- c. Head very large, about 50 (45-50) per cent of length without caudal. Skin naked. Distance between dorsal fin and base of middle caudal rays only about 1-1.5 in dorsal fin-base. Vertical fins moderate. Mouth very large, maxillary about 2 in head; forming largest part of upper boundary of mouth.

Anomalopterus Vaillant 1888.

- d. Distance from dorsal fin to base of middle caudal rays contained less than twice in dorsal fin base. Body with scales or with only a thin delicate skin without nodules. Head moderate or large, about 25-40 per cent of length without caudal, usually about 30 per cent or more.

- x. Upper dentition when present nearly or entirely confined to the premaxillaries which form the major portion of the upper margin of the mouth. Mouth small or moderate. Dorsal origin (except in *Leptochilichthys* and *Normania*) above or behind the origin of anal.

- o. Gill membranes large and expanded, covering the base and a considerable portion of the pectoral fins. Only 5 branchiostegal rays. Pectoral fins with a broad and high base, and relatively numerous rays (13-19). No teeth in upper jaws. Dorsal origin somewhat behind origin of anal. About 44-56 scales in lateral line.

Asquamiceps Zugmayer 1911.

- oo. 13 branchiostegal rays. Gill membranes normal, not covering pectoral fin base. Pectoral fins narrow. Upper jaws flattened and expanded, but without teeth. Snout blunt, thick and rounded. Pectorals with low and narrow base, about 11 rays. 8 pyloric ceca. About 55-60 scales in lateral line.

*Leptochilichthys*¹ Garman 1899.

- ooo. 6-8 branchiostegal rays (? *Normania*?). Gill membranes normal, not covering base of pectorals. Pectorals with only 8-10 rays (except *Normania*).

- n. Anal fin count less than 30 rays and not more than 50 per cent or 10 rays in excess of dorsal fin count. Scales moderate, less than 150 in lateral line.

¹ With reference to the relative development of maxillaries and premaxillaries and the relative positions of the vertical fins this genus obviously shows much closer relationship to the *Bathytroctes* group than to the *Alepocephalus* group.

- y. Dorsal (ab. 14) and anal (ab. 17) subequal in length, but with dorsal fin almost entirely in advance of anal. Mouth small. Maxillary not extending to center of eye. Scales relatively large, about 53 in lateral line.

Normania n. gen.

Alepocephalus andersoni (Fowler, 1934, p. 246, fig. 8). Genotype,

- yy. Dorsal and anal fins opposite or with anal fin origin slightly in advance of dorsal origin.

- z. Scales moderate or relatively large, 50-90 in the lateral line. Premaxillaries toothed, but not expanded as in *Xenognathus*.

- q. Snout and upper jaws not forming a pointed projection extending conspicuously beyond the lower jaw. 9-17 pyloric coeca.

Alepocephalus Risso.

- qq. Snout and upper jaws forming a pointed projection extending conspicuously beyond the lower jaw. Pyloric coeca few (7).

Halisauriceps Fowler 1933, p. 249.

Alepocephalus longiceps Lloyd 1909. Genotype.

- zz. Scales moderate, about 62 in lateral line. "Premaxillaries greatly expanded, without forming a pointedly projecting snout but forming a plate extending nearly horizontally backward, within which the deep mandible is completely received." Premaxillaries with teeth.

Xenognathus Gilbert 1915, p. 311.

- zzz. Premaxillaries and lower jaw without teeth. Premaxillaries not expanded.

Ericara Gill & Townsend 1897, p. 232.

- zzz. Premaxillaries with teeth, not ex-

panded. Scales small, about 140 in lateral line. Only 4 pyloric coeca.

Whitleydea Fowler 1934, p. 247.

Alepocephalus niger Günther 1887. Genotype.

- nn. Anal fin count over 30 rays, more than 15 rays in excess of, and about twice as great as the dorsal fin count. Scales very small, deciduous, with inconspicuous scale pockets, about 200 in the lateral line. Anal origin always well in advance of dorsal origin.

Conocara Goode and Bean.

- xx. Maxillary dentition comparable with, sometimes as great or greater than that of the premaxillaries which do not form the major portion of the upper margin of the mouth. Dorsal origin opposite or anterior to anal fin origin. Mouth moderate or large, never very small.

- o. Mouth very large, maxillaries extending far beyond posterior margin of orbit; so that the eye is located approximately above or anterior to the middle of the upper jaws. Teeth in jaws uniserial.

- n. Dorsal fin about twice as long as and with about twice as many rays as anal fins. Dorsal origin above ventral fins far in advance of anal origin. 9 branchiostegal rays.

Macromastax Beebe 1933, p. 81.

- nn. Dorsal and anal subequal (D 20 A 18). Anal origin opposite first third of dorsal fin base

Holbyrnia n. gen.

Bathytroctes innesi Fowler 1934, p. 252, fig. 14. Genotype.

- oo. Mouth moderate, maxillaries never extending conspicuously beyond vertical from posterior margin of orbit. Eye always far posterior to the middle of the upper jaws. Dorsal and anal fins subequal. 7 (?) branchiostegal rays.

- n. Premaxillary and mandibular teeth pluri-serial. Anal fin with fewer rays than dorsal. Dorsal origin well in advance of anal origin.

- y. Number of anal rays (11-16) $\frac{2}{3}$ or more of dorsal fin count (15-19). Anus behind origin of dorsal fin.

Narcetes Alcock.

- yy. Number of anal rays (7) only about $\frac{1}{4}$ or less of dorsal fin count (24). Anus before origin of dorsal fin.

Alcockella Fowler 1934, p. 255.

- nn. Teeth in jaws uniserial.

- y. Upper pectoral fin ray greatly produced, caudal lobes extended into long points. Scales small, about 100 in lateral line. Dorsal and anal origins approximately opposite. Pectorals with few rays (10).

Nemabathytroctes Fowler 1934, p. 252.

Bathytroctes longifilis Brauer 1906. Genotype.

- yy. Pectoral fins without produced rays. Caudal fin lobes normal.

- z. Dorsal and anal fins equal and approximately opposite (anal origin within the anterior fourth or less of dorsal fin base).

- q. Postclavicular organ present. Luminous organs not reported. Gill membranes moderate, gill opening starting from the level of the upper margin of the orbit.

Talismania Goode and Bean.

- qq. Postclavicular organ absent. Luminous organs in series on ventral portions of body with a single organ on each side at base of dorsal fin. Gill membranes very large, gill opening low, starting from the level of the center of the eyes.

Binghamia n. gen.

- zz. Anal origin always conspicuously behind origin of dorsal fin.

- q. Lower jaw projecting strongly forward in a pointed symphyseal knob continuing the dorsal profile of the snout beyond the premaxillaries. 17

pectoral rays. Premaxillaries without tusks.

Bajacalifornia Townsend and Nichols 1925, p. 8.

qq. Lower jaw not continuing dorsal profile of snout. Symphyseal knob smaller or absent.

r. Luminous organs in fixed numbers and well defined pattern on ventral half of body. Pyloric coeca strongly developed, lobate, branched, 6-7 proximal tubes carrying 16-27 distal diverticulae. Pectoral rays numerous (19-23). Scales when present small, about 80-100 in lateral line, sometimes absent. A conspicuous fleshy black supraclavicular process present above pectorals. Anal origin before middle of dorsal fin base.

Searsia n. gen.

Searsia koefoedi n. sp. Genotype¹

rr. Well defined luminous organs lacking. Supraclavicular process absent. No tusks. Scales moderate 40-70 in lateral line. 7-13 (?) pyloric coeca. Pectorals with 8-16 rays. Anal origin usually below or behind middle of dorsal fin base.

Bathytroctes Günther.

¹ Currently identified as *Bathytroctes rostratus* Günther, see page 12.

ALEPOCEPHALUS group

The number of pyloric coeca in the genotype of *Alepocephalus* are recorded as 12. Records are also available for 6 other species of this genus giving a range from 9–17. In most of the species the dorsal and anal fin counts only differ by 0–4 rays, and the fins are entirely separate. In a smaller group apparently consisting only of *A. bicolor* Alcock and *A. murrayi* Koefoed, the anal fin has 5–7 more rays than the dorsal, and its origin is slightly in advance of the dorsal origin, while the low scale counts (60–70) easily distinguish this group from *Whitleydea* and *Conocara*. It is of interest to note that the lowest count of pyloric coeca reported in the genus *Alepocephalus* (9 in *A. bicolor* Alcock, count not given for *A. murrayi* Koefoed) is found in this group; the remaining records, giving 12 to 17 coeca.

If *Alepocephalus longiceps* Lloyd (with only 7 rudimentary pyloric coeca combined with only 3 rays more in anal than in dorsal fin, and only 52 scales in the lateral line) represents a separate offshoot of the *Alepocephalus* group, for which Fowler 1933, p. 247 introduced a new genus *Halisauriceps*, it seems indicated that a triple correlation might exist within the rest of the *Alepocephalus* group between decreasing number of pyloric coeca, increasing difference between vertical fins (increasing anal fin count) and increasing number of scales. This correlation may already, as above pointed out, be apparent within the genus *Alepocephalus* itself according to the pyloric appendage counts so far recorded. In *Whitleydea* Fowler there are only 4–8 pyloric coeca, 6–11 more rays in anal than in dorsal fin ($1 : 1 \frac{1}{3}$ – $1 \frac{1}{2}$), and 120–140 scales in lateral line. In *Conocara* Goode and Bean there are only 5–7 pyloric coeca, about 18 more rays in anal than in dorsal fin (about $1 : 1 \frac{1}{2}$), and about 200 scales in the lateral line.

On this basis both *Halisauriceps*, *Whitleydea* and *Conocara* are tentatively retained as distinct from *Alepocephalus*.

Normania new genus

The genotype *Alepocephalus andersoni* Fowler (1933, p. 246, fig. 9) is so distinct from all other members of the *Alepocephalus* group by the relative positions of its vertical fins that it is difficult to understand how it could be described as a new species of *Alepocephalus* parallel with the introduction of so many new genera and subgenera based upon less patently valid distinctions. From the greatly enlarged axillary scale above the pectoral fin base clearly shown in the figure, it does indeed seem indicated that the genus might possibly be Clupeoid rather than Alepocephalid. Since this feature is not mentioned in the text, however, the genus is tentatively included in these suggestions for a revision of the *Alepocephalidae* to avoid the possibility of incompleteness. A summary of the generic diagnosis developed in the preceding key is given herewith:

Dorsal and anal fins short (D 14, A 17) with anal origin below the posterior part of dorsal fin base. Pectorals large, with a greatly enlarged scale above their axil (? only in figure), but only a moderate number of finrays (15). Scales relatively large (53). Mouth very small, maxillary only extending slightly beyond anterior margin of orbit. Head of Microstomid appearance (ac. to figure).

Genus **Conocara** Goode and Bean

5-7 pyloric coeca have previously been recorded for this genus, which apparently only contains 2 species, namely, *C. macdonaldi* Goode and Bean and *C. macroptera* (Vaillant). In the only specimen here recorded, 7 simple pyloric coeca are found to be present in a transverse and symmetrical ring around the pylorus, an arrangement by which the form is sharply distinguished from all of the 4 alepocephalid species of the *Bathytroctes* group here reported upon (see Figure 7). It would be of great interest to know whether the same arrangement should also obtain in the genera of the *Alepocephalus* group more closely related to *Conocara*.

? **Conocara macroptera** (Vaillant 1888)

1 specimen, No. 3717 B. O. C. Station 54, April 12, 1927. 21° 15' 40" N. 71° 17' 06" W. 7500 feet wire out.

The above specimen which is too small to afford good comparison with the large types of *C. macroptera* and *C. macdonaldi* has been tentatively identified as *C. macroptera* chiefly on account of the size of its eyes, which are scarcely contained 4 times in the length of the head as in *C. macroptera* (5 in *C. macdonaldi*), while the head, on the other hand, is only contained about 3 1/3 times in the length without caudal as in *C. macdonaldi* (4-4 2/3 in *C. macroptera*). The depth of body (9 in length) is even less than reported for *C. macroptera* (6 2/3-6 3/4. 5 3/4 in *C. macdonaldi*). While it is possible that the specimen might represent a third distinct species, more material of larger size is patently needed before this point can be decided. Some of the measurements are given herewith:

Length without caudal fin 69 mm. Proportions in per cent of length without caudal fin: Head 31. Snout 10.5 Eye 8. Maxillary 9.5. Greatest width of skull 12.2. Interorbital width above centre of orbits 5. Depth 11.5. Snout to dorsal fin 67. Snout to anal fin 55.

Finrays: D. 20. A. 36.

Genus **Asquamiceps** Zugmayer

This genus seems easily distinguished from *Alepocephalus* by the greatly expanded and extended gill cover, and by the short, broad and rounded pectoral fins which are inserted comparatively high on the side of the body with their bases hidden under the opercular membranes.

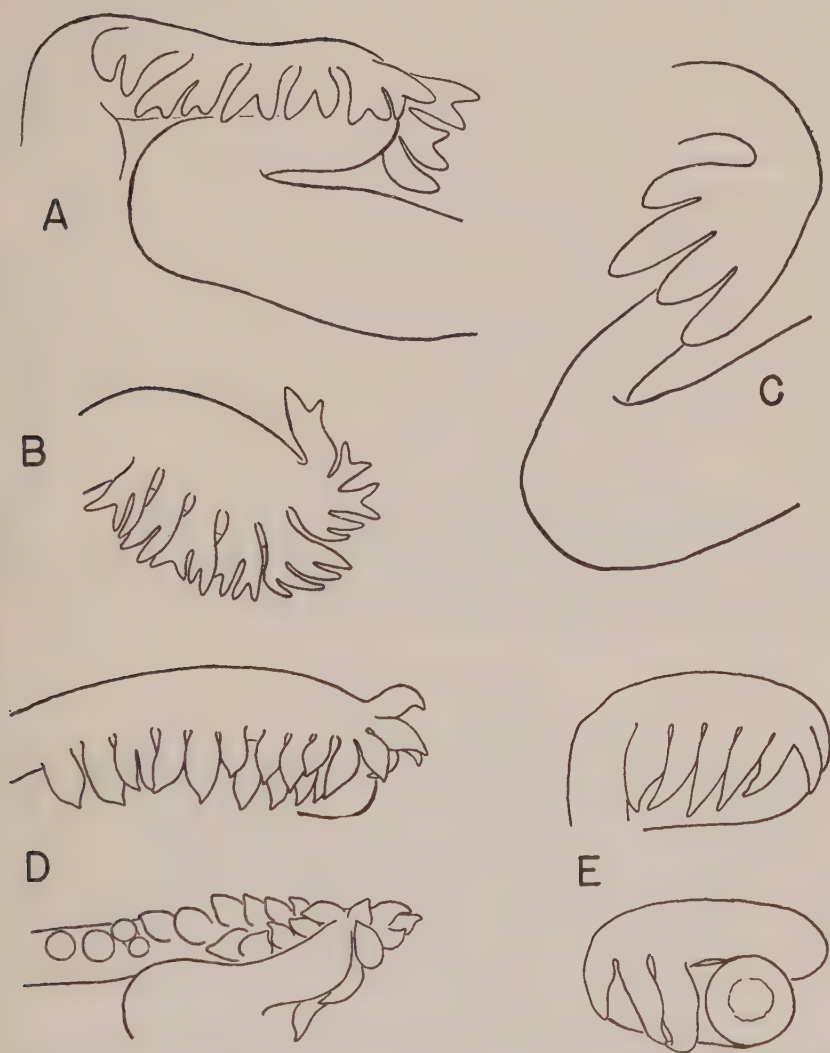


Figure 1. Pyloric appendages of Alepocephalidae. A. *Searsia koefoedi*. B. *Searsia polycoca*. C. *Conocara macroptera*. D. *Bajacalifornia drakei* (2 views). E. *Binghamia microphos* (2 views).

Apart from the species which have already been assigned to this genus, *Alepocephalus hjorti* Koefoed undoubtedly and *A. macrolepis* Koefoed probably belong here. While the recorded pectoral fin counts in the rest of the genus are generally high (13-14 in the genotype *A. velaris* Zugm.; 16-19 in the others) thereby providing also a fairly good numerical distinction from the genus *Alepocephalus* (highest reported pectoral count 13) *Alepocephalus macrolepis* Koefoed, which in all morphological aspects above mentioned seems a typical *Asquamiceps*, is reported to have only 10 pectoral rays, but so long as only one specimen is known the possibility of accidental damage or individual abnormality must still be considered. *Asquamiceps macrolepis* (Koefoed) is also atypical in having 5 more rays (maximum 2 in the others) in anal than in dorsal fin and the anal origin noticeably in advance of the dorsal.

Fowler (1933, p. 248) has introduced a new subgenus of *Asquamiceps* under the name of *Megalepocephalus*, defined chiefly by its scaly head. The author has had no opportunity to study the merits of this distinction which if valid, may be difficult to make in actual practice.

Genus **Whitleydea** Fowler 1934

In addition to the genotype *Alepocephalus niger* Günther 1878, with only 4 pyloric coeca and about 140 scales in lateral line, *A. microlepis* Lloyd 1909 would also seem to belong to this genus differing from *W. niger* in having 8 pyloric coeca and only about 125 scales in lateral line.

BATHYTROCTES group

Searsia new genus

The species for which this new genus is herewith introduced is currently identified as *Bathytroctes rostratus* Günther. This identification, however, apparently requires an entirely unwarranted assumption of ontogenetic changes with regard to luminous organs clearly expressed by Norman (1930, p. 268) in the statement that these organs "seem to disappear altogether in the adult fish." Such an ontogenetic disappearance of the luminous organs in *Searsia koefoedi* n. sp. (nec. *Bathytroctes rostratus* Günther) is contrary to all available evidence which may be regarded as quite complete on this point as the following account will show.

The luminous organs are present without indication of degeneration in the largest specimens here reported upon and also in the largest original example (56 mm.) described by Beebe (1933, p. 48 and fig. 8 C and D). The Luminous organs are also clearly described and figured by Brauer (1906, p. 17, plate XIV, fig. 2) in an apparently unreduced condition in a specimen 81 mm. long without caudal. Finally Koefoed (1926, p. 52) describes these organs as present also in his two specimens, the largest of which (about 160 mm. total length, 138 mm.

without caudal fin) is of approximately the same size as the type of *Bathytroctes rostratus* Günther (165 mm. total length, 147.5 mm. standard, *vide* Günther and Koefoed).

Günther's description and figures of a pair of short, flat, projections of the premaxillaries, toothed at their extremity, is also more in accordance with the lip-like projection of the premaxillaries observed in several other species of *Bathytroctes* (see for instance Koefoed 1926, p. 48) than with conditions in *Searsia koefoedi* as already remarked upon by Koefoed (1926, p. 52).¹ Koefoed also points out a number of other specific discrepancies between Günther's description and his own material of comparable size. Adding the additional distinguishing feature of the numerous pyloric coeca it therefore seems fairly certain that the form currently identified as *Bathytroctes rostratus* cannot actually belong to that species, but is both specifically and generically distinct.

Actually *Searsia* is probably more closely related to *Talismania* than to *Bathytroctes*. Norman (1930, p. 269) thus mentions a supraclavicular process in an adult of *Talismania homoptera* Vaillant, while this feature has never been described from the genus *Bathytroctes*. Norman also reports 2 or 3 forwardly directed teeth anteriorly in each premaxillary in the same specimen of *T. homoptera*. Unfortunately the number of pyloric coeca has not been recorded for a single species of *Talismania* (3 species of *Bathytroctes*), but *Talismania* can always be easily distinguished from *Searsia* by the fewer pectoral rays, the position of the vertical fins, and the absence of luminous organs.

A synopsis of the generic diagnosis developed in the preceding key is given herewith:

Dorsal and anal fins subequal with reference to length and fin-ray counts but the origin of dorsal fin is always well in advance of the origin of anal. Ventrals inserted approximately midway between tip of snout and base of caudal fin. Pectorals small, but with numerous (more than 20) rays. Each premaxillary with an enlarged tooth anteriorly, directed horizontally forward in the manner of a tusk. Pyloric appendages strongly developed, flat, lobate and branched, forming a single, sagittal and asymmetrical horseshoe series surround the pylorus and descending almost the entire length to the first caudad limb of the large intestine on one side. Proximal count of pyloric appendages 6; distal count of terminal branches about 18-25. Luminous organs in well-defined patterns. 3 thoracic organs in a transverse series, or a single, linear, transverse,

¹ Figure 2 gives a camera lucida drawing from Günther's illustration of the snout of *Bathytroctes rostratus* in dorsal view. It seems difficult to understand how this figure can be interpreted to represent the tusk-like dentition of *Searsia koefoedi* (see Fig. 3) as done by Beebe 1933, fig. 9D, p. 41, and the postclavicular organ indicated by Beebe in the same figure seems quite undiscernable in Günther's illustrations, nor is it mentioned in his description. The anterior ends of the snouts in *Searsia koefoedi* and *S. polycoeca* are shown for comparison in Figure 3.

thoracic organ in the mid-ventral below and somewhat behind the pectoral fins; one supraventral organ on each side above the anterior end of the ventral fin base; one or more subventral organs in or immediately anterior to the region between the diverging ventral fin bases; a supra-anal organ on each side im-



Figure 2. Camera lucida drawing from Günther's illustration of the snout of *Bathytroctes rostratus* in dorsal view.

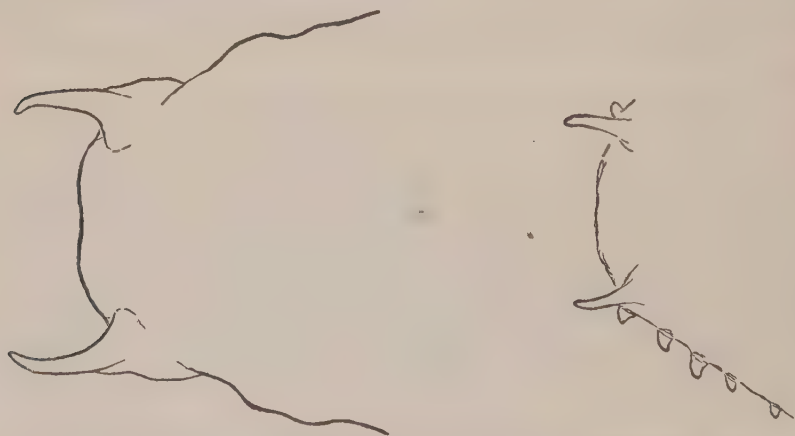


Figure 3. Dorsal views of snouts of *Searsia koefoedi* (left) and *S. polycoeca* (right).

mediately above the anus; and usually 1 or 2 organs along the base of anal fin and 1 along the base of dorsal. In addition to these 1 or 2 small postventral organs may occur between or immediately behind the ventral fin bases, a median preanal organ may be found before the vent, and median subcaudal

organs may occur below the free caudal peduncle. There also normally seems to be 4-6 elongate luminous organs on the branchiostegal membranes arranged along the rays. The black postclavicular organ is always present. Lower jaw does not extend beyond the premaxillaries or the snout and the symphyseal knob is inconspicuous or absent. Mouth moderate or large, maxillaries extending at least to the centers of the orbits. Eyes fairly large, 3-4 in head. Adults normally probably always scaly, but scales quite deciduous and late to develop. Head moderate, about $2\frac{2}{3}$ - $3\frac{1}{3}$ in length without caudal.

Teeth present in premaxillaries, maxillaries, vomer and lower jaw, sometimes also on palatines. Teeth in jaws in single series, except at the anterior end of lower jaw, where a short external row is found below the regular series. Gill membranes moderate; gill opening high, beginning at the level of the upper margin of the orbit, above the vertebral column (mid-lateral myoseptum).

Although the writer is inclined to believe that the species described in the following as *S. Koefoedi* is that which is most common and therefore has probably also been represented in the material previously referred to *Bathytroctes rostratus* as listed in the tentative synonymy on the following page, it is obviously quite possible that more than 2 species may be found to exist and that some of the previous records might therefore refer to still other species than the 2 herein described. Some suggestions of possible specific distinctions already seem indicated particularly in Norman's and Beebe's accounts and figures. Both authors show 3 separate thoracic organs in a transverse series (Norman, 1930, pl. II, fig. 3; Beebe, 1933, fig. 8D) instead of the single continuous linear organ found in *S. koefoedi* and *S. polycoeca*; both show the anterior subventral organs well in advance of the supraventrals, and the presence of a median preanal organ before the vent; contrary to our findings in the two species here reported upon. Since material exhibiting these deviating features is not available to the author, he does not consider the introduction of a new specific designation appropriate at this time, while the possibility of a distinct species of the particular type above discussed is indicated in the following key.

Key to the Genus *Searsia*.

- I. A single continuous linear transverse thoracic luminous organ. Anterior subventrals between or behind the supraventrals. No median preanal organ.
 - A. Head moderate, about 30 per cent of length without caudal. Maxillary only about 15 per cent or less of length without caudal, falling conspicuously short of the vertical from the posterior margin of the orbit. *S. koefoedi*, n. sp.
 - B. Head large, about 37 per cent of length without caudal. Maxillary about 20 per cent, ending approximately at the vertical from the posterior margin of orbit. *S. polycoeca*, n. sp.

- II. Three separate thoracic photophores in a transverse series. Anterior subventral photophores in advance of the supraventrals. A median preanal luminous organ present. *S. n. sp.?*

? *Bathytroctes rostratus* (nec Günther).

Norman 1930, p. 268, fig. 1, pl. II, fig. 3; Beebe 1933, p. 36, fig. 8 A-D, nec fig. 8 E.

Table of Measurements of *Searsia* spp.

Species		koefoedi		polycoecca
Station		18 Type	9	58 Type
Length without caudal, mm.		69	47	48
Head	Per cent of length without caudal	30.4	29.8	37.0
Eye		10.0	10.6	10.4
Maxillary		14.5	14.9	20.8
Snout		8.0	7.0	9.4
Depth		19.0	17.0	19.0
Snout—D		64.5	64.0	64.5
Snout—V		51.0	51.0	55.0
D base		18.5	20.1	17.7
A base		17.0	18.5	15.6

***Searsia koefoedi* new species**

? *Bathytroctes rostratus* (nec Günther); Brauer, 1906, p. 17, pl. XIV, figs. 2, 3; Holt and Byrne, 1908, p. 48, pl. IV, figs. 3-5; Zugmayer, 1911, p. 5, pl. I, fig. 1; Koefoed, 1926, p. 51; Norman, 1930, p. 268, fig. 1, pl. II, fig. 3; Beebe, 1933, p. 36, fig. 8 A-D, nec fig. 8 E, fig. 9 a-c, nec fig. 9 d.¹

1 specimen, No. 3720 B. O. C. TYPE. Station 18, March 10, 1927. 23° 39' 25" N. 76° 41' W. 7000 feet wire out.

1 specimen, No. 3721 B. O. C. Station 9, March 1, 1927. 23° 55' 25" N. 77° 09' 10" W. 4000-7000 feet wire out.

1 specimen, No. 3723 B. O. C. Station 16, March 9, 1927. 23° 49' 15" N. 76° 58' 30" W. 7000 feet wire out.

Premaxillaries with a couple of slightly enlarged downwards-directed teeth below the base of the tusk, followed by 4-6 small teeth. Maxillaries with about 40-50 minute teeth. Maxillary forming more than $\frac{2}{3}$ of the free margin of the upper jaws. Lower jaws with numerous minute teeth in a single series except at the anterior end where a short external series also occurs. A pair of teeth on vomer, none on palatines. Maxillaries ending well in advance of posterior margin of orbit.

¹ How the details shown in Beebe's figure 9d could be drawn after Günther's description and figure as stated in the legend is difficult to understand.

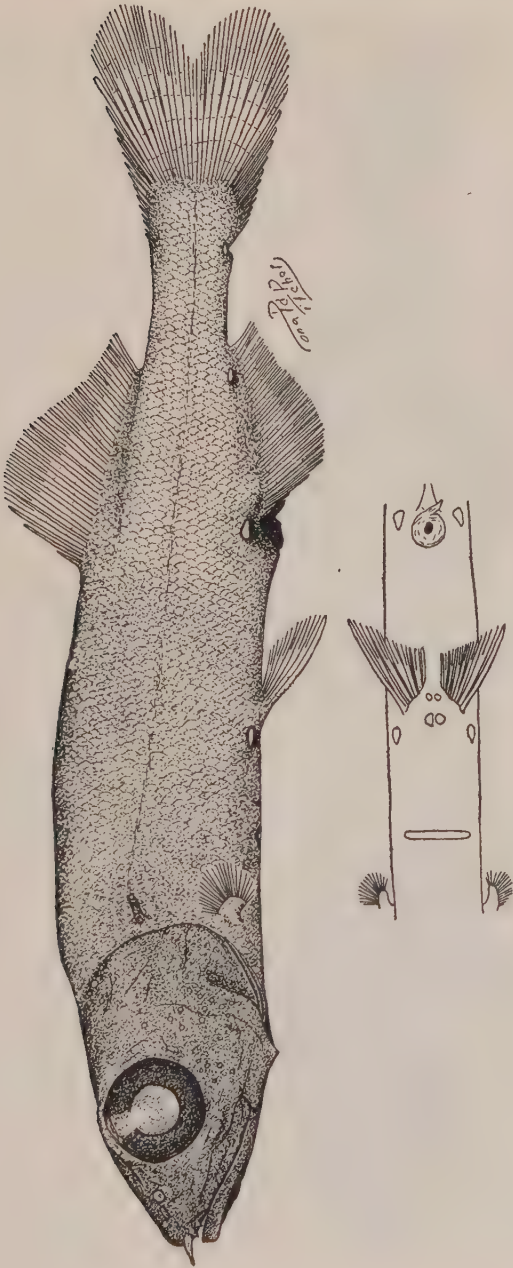


Figure 4. *Searsia koejoedi* n. sp. With ventral view of luminous organs. Drawn by D. T. Pitcher.

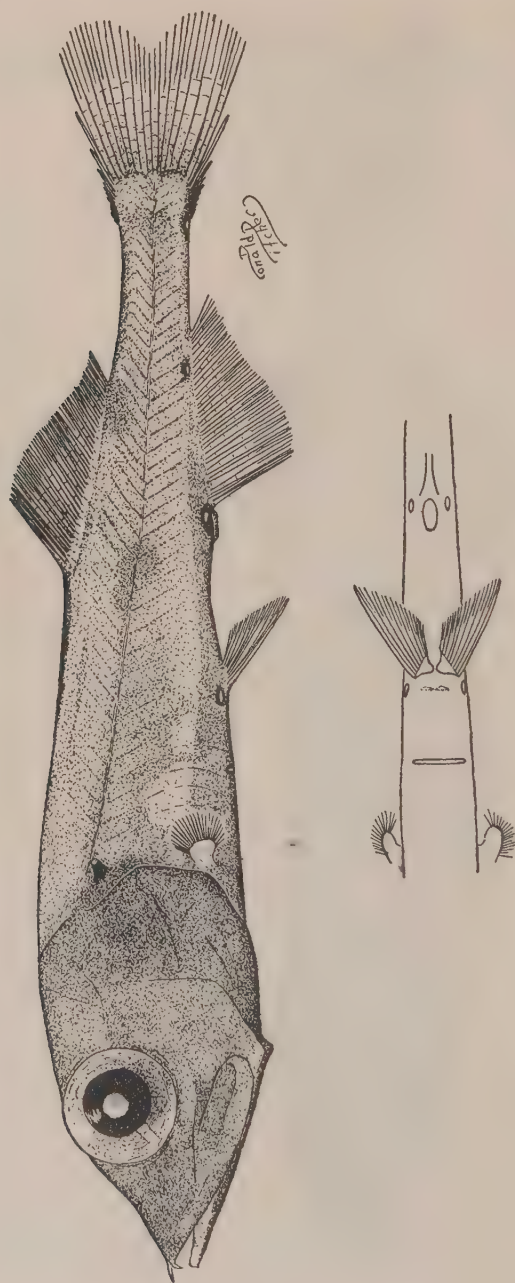


Figure 5. *Searsia polycoca* n. sp. With ventral view of luminous organs. Drawn by D. T. Pitcher.

Gill-rakers long, 4.4 per cent of length without caudal; 7/1/19 in the first arch.
D. 21. A. 20. P. 23.

Scales small, deciduous, practically all lost in type, but scale pockets very distinct; about 85 in lateral line.

The measurements are given in the table on page 16, and the general appearance will be evident from figure 4. Eyes circular.

A single linear, transverse, thoracic photophore situated somewhat nearer to the pectorals than to the ventrals. 2 subventrals, their anterior margin opposite the posterior margin of the supraventrals. 2 very small postventrals situated between the posterior halves of the ventral fin bases (not behind the ventrals). One supra-anal on each side above the vent. One on each side above the 3d-4th anal pterygiophore counted from behind. A pair (one on each side) at the anterior end of the subcaudal series of procurent caudal spines. No median pre-anal luminous organ, and no luminous organ at the base of dorsal fin.

Searsia polycoeca new species

1 specimen, No. 3719 B. O. C. TYPE. Station 58, April 20, 1927. 32° 24' 15" N. 64° 29' W. 10,000 feet wire out.

As the following description will show, the distinction between *S. polycoeca* and *S. koefoedi* is based upon a number of other features (e. g. dentition, luminous organs, etc.) in addition to those already mentioned in the key.

Premaxillaries with an enlarged, decurved, downwards-directed tooth below the base of the tusk, followed by 4 moderately enlarged, widely-spaced teeth. Tusk smaller than in *S. koefoedi*, other teeth larger throughout. Premaxillaries forming only about $\frac{1}{4}$ of the free margin of the upper jaws. Maxillaries with about 20-25 teeth. Lower jaw with small teeth in a single series and a few external teeth anteriorly. 2 teeth on vomer and a pair of teeth anteriorly in each palatine. Maxillaries reaching approximately to posterior margin of orbit.

Gill-rakers long, 4.7 per cent of length without caudal; 6/1/15 in the first arch, thinner than in *S. koefoedi* and therefore appearing more open.

D. 20. A. 17. P. 22-23.

Scales absent, with no distinct evidence of scale pockets, but the skin, although unbroken, would appear to have been considerably rubbed.

The measurements are given in the table on page 16, and the general appearance will be evident from figure 5. Eyes circular.

Luminous organs as described for *S. koefoedi* with only the following exceptions: The subventrals which are extremely vague are situated opposite the centers of the supraventrals. The postventrals, which are much larger and very well defined by their blackly-pigmented cover, occupy most of the space between the ventral fin bases, having their center between the anterior halves of the fins. The posterior supra-anal photophore occurs at the third pterygiophore counted from the rear.

Genus *Xenodermichthys* Günther 1878*Xenodermichthys copei* Gill 1884*Xenodermichthys socialis* Vaillant 1888.

1 specimen, No. 3718 B. O. C. Station 56, April 13, 1927. 21° 20' 15" N.
71° 13' 20" W. 6500 feet wire out.

X. socialis would seem to have been retained as a distinct species from *X. copei* mainly on a vague assumption that the western Atlantic individuals might be found to differ specifically from those occurring in the east, while it appears to have been tacitly or explicitly recognized that the morphological differences so far reported are utterly inadequate to support this assumption. The de-

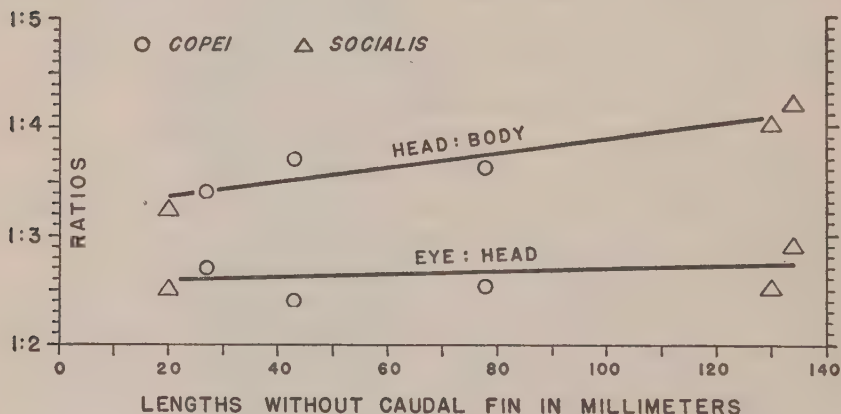


Figure 6. Ontogenetic changes in Head: Body and Eye: Head ratios in *Xenodermichthys copei* (incl. *X. "socialis"*).

scription of the type of *X. copei* gives eye only 2 in head and head $3\frac{3}{8}$ in body, while the eastern form, *X. socialis*, was originally reported to have a somewhat smaller head (4 in body) and smaller eyes ($2\frac{1}{2}$ in head). Subsequent reports on new material from the eastern Atlantic (Holt and Byrne 1908, p. 48) extends the range of variation for *X. socialis* to : head $4-4\frac{1}{4}$ in body, eye $2\frac{1}{2}-2\frac{3}{4}$ in head; in adult specimens (head $3\frac{1}{4}$, eye $2\frac{1}{2}$ in a specimen 20 mm. long). In a later report by Beebe (1933, p. 87) are described some adolescent specimens from the western Atlantic which he refers to *X. copei* "in view of their geographical occurrence" but with the comment that they "agree slightly better with the descriptions of *X. socialis*" given by Holt and Byrne than with that of the larger type specimen of *X. copei*. In Beebe's largest adolescent the head is contained 3.4 times in the length without caudal (27 mm.), and the eyes 2.7 times in the head. In the western Atlantic specimen here reported upon, which

measures 43.5 mm. without caudal fin, the head is contained 3.7 times in this measurement, and the eyes 2.4 times in the head. Finally Dr. L. P. Schultz, of the U. S. National Museum, has kindly remeasured the type of *X. copei*, finding the head (21.5 mm.) to be actually contained 3.62 times in the length without caudal, and the eyes 2.53 times in the head (horizontal diameter of orbit 8.5 mm.).

If the various proportions thus reported are plotted against length without caudal fin, they give the result shown in figure 4, from which it may be seen that there is apparently absolutely no reason for considering *A. socialis* to be distinct from *A. copei* which by priority becomes the designation for the only Atlantic species of *Xenodermichthys* so far known.

Genus **Talismania** Goode and Bean

Of the type species of this genus *T. homoptera* (Vaillant) we know from Norman's account (Norman 1930, p. 269) that the postclavicular organ is still present in specimens up to 100 mm. length without caudal fin. When this organ, which if it changes ontogenetically at all, apparently tends to diminish in relative size and conspicuousness with age, is completely absent in a specimen of only 44.5 mm. length without caudal a generic distinction seems warranted, particularly when supported by several other features of equal importance. On this basis the genus *Binghamia* has in the following been separated from the genus *Talismania* to which it would otherwise be referred in the absence of its luminous organs and without recognition of the significance of the postclavicular organ in *Talismania*.

This distinction, however, creates an unfortunate, but temporary, condition of uncertainty with regard to the other species previously referred to *Talismania*, since information concerning presence or absence of photophores and postclavicular organs is not available for any of these forms. It might be mentioned, however, that *T. mollis*, at least, has been repeatedly re-illustrated from new material (Roule 1919, Koefoed 1926) without any indication of the normally very conspicuous postclavicular organ, and it therefore seems reasonable to assume that it must actually be absent in this form, in which case the possibility of 3 separate genera among the species previously referred to *Talismania* seems indicated.

The genotype, *T. homoptera*, is also characterized by relatively small scales, 64-75 in the lateral line; and (according to Norman's figure) by a small or moderate gill membrane with a high gill opening beginning at the level of the upper margin of the orbit, in which respect it therefore also seems to differ generically from the genotype of *Binghamia*.

Binghamia new genus

No postclavicular organ. Small luminous organs in regular series, particularly along the base of anal fin, and in median series in the thoracic and subcaudal regions. Teeth small and uniserial in premaxillaries, maxillaries and lower jaw. Few or absent on vomer and palatines. No enlarged fangs or tusks. Dorsal and anal fins equal and opposite. Scales moderate, very deciduous. Maxillaries forming major part of free margin of upper jaw, not extending beyond anterior half of orbit. Pyloric coeca about 9, large, but simple, embracing contiguous part of stomach. Gill membranes very large, without covering the bases of the pectoral fins. Gill opening low, starting from the level of the centre of the eye below the medio-lateral myoseptum.

The reasons for separating this genus from *Talismania* are given on page 21. Genotype.

Re-examination of most of the species previously referred to the genus *Talismania*, with the exception of the genotype *T. homoptera*, would be desirable to determine their proper classification with reference to the genera *Talismania*, *Binghamia* and a possible third genus of this group.

Binghamia microphos new species

1 specimen, No. 3724 B. O. C. Station 22, March 12, 1927. 23° 37' 25" N. 77° 15' 10" W. 7000 feet wire out.

Length without caudal fin 44.5 mm. Proportions in per cent of length without caudal: Head 34. Snout 9.5. Eye 11.2. Interorbital width 3.8. Greatest width of skull 13. Maxillary 12.5. Greatest depth 18. Depth of caudal peduncle 8.5. Snout to dorsal fin 66. Snout to ventrals 52. Dorsal fin base 19.5.

D. 20. A. 21. P. 16. About 40-45 scales in the lateral line? (only a few scales actually preserved on entire body).

Gill-rakers long, about 3.5 percent of length without caudal; 7/1/19 in first arch.

Pyloric coeca 9, large but simple, forming an assymmetrical horseshoe around the pyloric region descending along the first limb of the convolute intestine. The coeca almost completely embrace the contiguous portion of the stomach.

Maxillaries and premaxillaries with about 15 very small teeth each, in a single series. Premaxillaries forming about $\frac{1}{2}$ of free margin of upper jaws. Lower jaw with a single series of minute teeth, without external teeth anteriorly. Vomer and palatines toothless. Maxillaries extend only slightly beyond the anterior margin of the orbit.

Eye almost circular. Snout short, obtuse. Gill membranes large, but not covering pectoral fin bases. Dorsal and anal fins subequal and opposite. No postclavicular organ.

3 apparently luminous organs ("luminous scales") in a short median series below the pectorals, the middle organ being situated between the tips of the

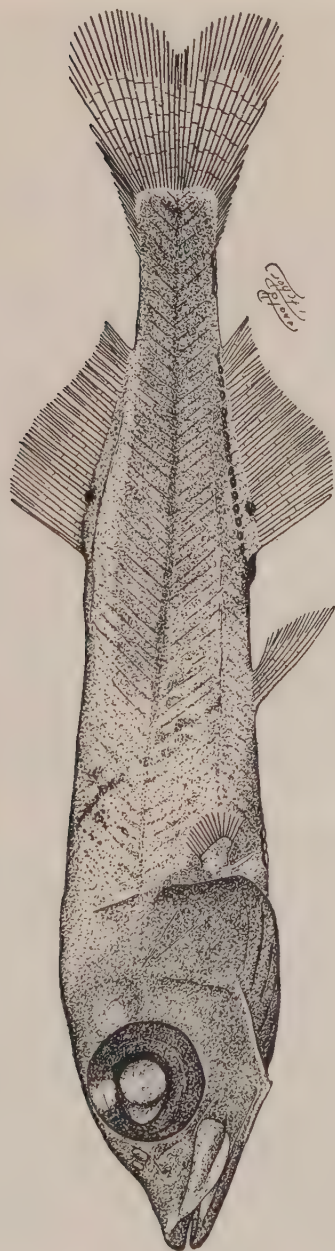


Figure 7. *Binghamia microphos* n. sp. Drawn by D. T. Pitcher.

postcleithra. Ventral fins with a conspicuous black pigmentation along the first and second rays and a round dot at the base of the third ray, forming a characteristic pattern. About 15 well-marked, but very small black organs with associated transparent tissue in a series on each side of the anal fin along the level of the proximal ends of the pterygiophores, with the first organ immediately behind the vent (at base of 1st pterygiophore, but in advance of first anal ray) and the last organ at the base of the third pterygiophore from behind. Well below this series at the bases of the pterygiophores a single larger organ is situated on each side at the base of the 6th anal ray. A similar, but still somewhat larger protruding organ is found at the base of the 7-8th dorsal ray, but no organs at the bases of the dorsal pterygiophores. 5 tiny apparently luminous scales form a median series extending from the anterior end of the procurent infracaudal spines about halfway to the base of anal fin.

Binghamia microphos is in general form suspiciously similar to *Bathytroctes antillarum* Goode and Bean, but Messrs. Schultz and Reid of the U. S. National Museum, who have kindly compared a sketch of *B. microphos* with Goode and Bean's type (125 mm. without caudal fin) report the complete absence of any luminous (?) organs. While all the other presumably luminous organs are very inconspicuous also in *B. microphos* and at least those in the thoracic region perhaps easily lost with the scales, this is probably not true of the larger, wart-like organs occurring in pairs on each side of the base of dorsal and anal fins. *B. microphos* is therefore here tentatively described as a new species, while the definition of the genus *Binghamia* also rests upon other morphological characters (absence of postclavicular organ, height of gill opening, size of gill membrane, etc.) adequately differentiating it both from *Talismania* and from *Bathytroctes*, whether *Bathytroctes antillarum* should subsequently be found to pertain to this genus or not.

Genus **Bajacalifornia** Townsend and Nichols

If the genus *Bajacalifornia*, which so far rests only upon the very weak foundation of one single none too well defined morphological character, is actually valid it seems evident that Beebe's *Bathytroctes drakei* must be referred to this genus (see particularly Beebe 1933, fig. 3B, p. 28). The genus is here only tentatively maintained as distinct from *Bathytroctes* in view of the possibility that other features such as, for instance, the pyloric coeca below described might perhaps be found to provide an adequate basis for a satisfactory generic diagnosis. It seems possible that the relatively high pectoral fin counts (16-17) might also be significant in correlation with other features.

Only two species belonging to this genus seem to be known to science, namely *B. drakei* (Beebe) and *B. burragei* Nichols and Townsend (unless some other forms described under the generic designation of *Bathytroctes* should actually also belong here) and even these two species do not seem very clearly distinguished on the basis of present knowledge.

Bajacalifornia drakei (Beebe 1929)

? 1 specimen, No. 3722 B. O. C. Station 41, March 30, 1927. N. 22° 31' 15". W. 74° 26' 20". 10,000 feet wire out.

It is only with considerable hesitation that the above recorded specimen is here tentatively identified with *B. drakei* (Beebe) which it greatly resembles in general shape of head (including jaws), body and the strongly elliptic eyes, and with which it furthermore agrees in general bathymetric region of capture. Against this identification stands Beebe's description of the maxillaries as barely reaching to the anterior rim of the eye-ball, and the scalelessness of the type and smaller specimens previously recorded. On the other hand, it seems quite possible that these features may both be juvenile, Beebe's type and largest specimen measuring only 29 mm. without caudal fin as compared with 68 mm. in our example.

In comparison with the description of the genotype *B. burragei* Townsend and Nichols from the Gulf of Lower California, which was 120 mm. long without caudal fin, our specimen seems to differ only by its much slenderer body and by its geographical occurrence; while it is in good accordance with all other features mentioned in Townsend and Nichols' description. The difference in body depth might, of course, again be related to the difference in size between the specimens, and there is consequently still room for considerable doubt as to whether the Atlantic and the Pacific individuals can actually be regarded as specifically distinct from each other. The specimen here reported upon gave the following measurements and counts, and its general appearance is indicated in the accompanying figure.

Length without caudal fin 68 mm. Proportions in per cent of length without caudal fin: Head 32. Horizontal diameter of eye 10.5. Vertical diameter of eye 7.5. Snout 10.5. Orbit to end of symphyseal knob 11.2. Lower jaw 19. Snout to end of maxillary 14.2. Greatest cranial width 11.2. Interorbital width 3.1. Depth at nape 12.2. Depth at ventral fin base 8. Depth of caudal peduncle 7. Snout to dorsal fin 64. Snout to ventrals 58. Snout to annal 70. Dorsal fin base 15. Anal fin base 10.3.

D. 16. A. about 12. P. about 16. About 52 scales in lateral line.

The arrangement and appearance of the pyloric coeca differs strikingly from that of the other Alepocephalids here reported upon (see fig. 1, p. 11.) The coeca are bulbous, simple (with one exception) and with pointed tips, forming a horseshoe around the pylorus anteriorly and descending the anterior portion of the almost straight intestine for a considerable distance. The anterior half of this descending series forms a double row of appendages, a feature which has not been observed in any of the other species here reported upon. The total number of appendages is 21, and the third from the posterior end is deeply branched.

Premaxillaries with about 10-12 small teeth. Maxillaries, which form about

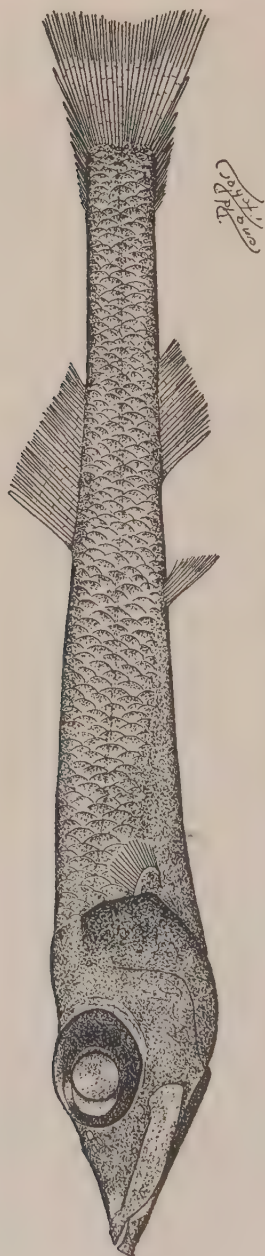


Figure 8. *Bajacalifornia drakei* (Beebe). Drawn by D. T. Pitcher.

$\frac{2}{3}$ of the free margin of the jaws, with about 30 teeth. Lower jaw with small teeth in a single series without outer teeth in front. 2-3 widest teeth on each side in the vomer, 5-6 on each palatine.

Gill-rakers very fine, about 4.4 per cent of length without caudal; $5\frac{1}{18}$ in first arch.

Scales all lost but scale pockets very distinct.

Eyes strongly elliptic; ratio of horizontal to vertical diameter about 4:3. Snout depressed, sharply pointed in lateral view. Gill membranes fairly large, but not covering pectoral fin bases. Gill opening beginning at the level of the upper margin of the orbit.

Family OPISTHOPROCTIDAE

Genus *Opisthoproctus* Vaillant

The genus *Opisthoproctus* is in many respects one of the most interesting of all genera of deep-sea fishes.

Roule (1916) has pointed out the resemblance of many of its skeletal features to teratological, specifically rachitic, abnormalities. Regular morpholog-

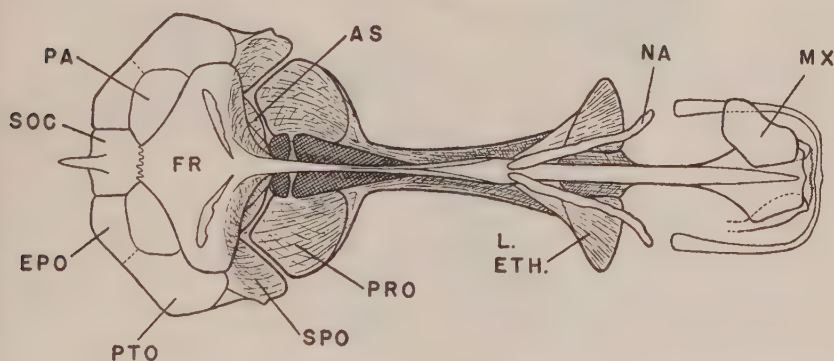


Figure 9. Dorsal view of skull in *Opisthoproctus soleatus*. Explanation of lettering for figures 9-12. ART = articular. AS = alisphenoid. B. HY = basihyals. C. HY = ceratohyals. DE = dental. ECPT = ectopterygoid. ENPT = entopterygoid. EPO = epiotic. FR = frontal. GL. HY = glossohyal. HYOM = hyomandibular. IOP = interopercle. L. ETH. = lateral ethmoid. MX; MAX = maxillary. MPT = metapterygoid. NA = nasal. OP = opercle. PA = parietal. PAL = palatine. PRO = prootic. PTO = pterotic. QUAD = quadrate. SOC = supraoccipital. SOP = subopercle. SPO = sphenotic. SYM = symplectic. U. HY = urohyal.

ical characteristics, perhaps even more strongly suggestive of pathological conditions, have been described by Regan and Trewavas (1930) especially in the peculiar lack of ossification of the anterior vertebrae in some Stomiatooids (*Eustomias*). A weakly ossified skeleton may perhaps be said to be a normal

feature of deep-sea fishes. In this connection it may be pointed out that the vitamin (D) chiefly concerned in the control of skeletal ossification in vertebrates can be directly produced by light and is dependent upon the presence of light for its production by biological processes. It is furthermore not of indef-

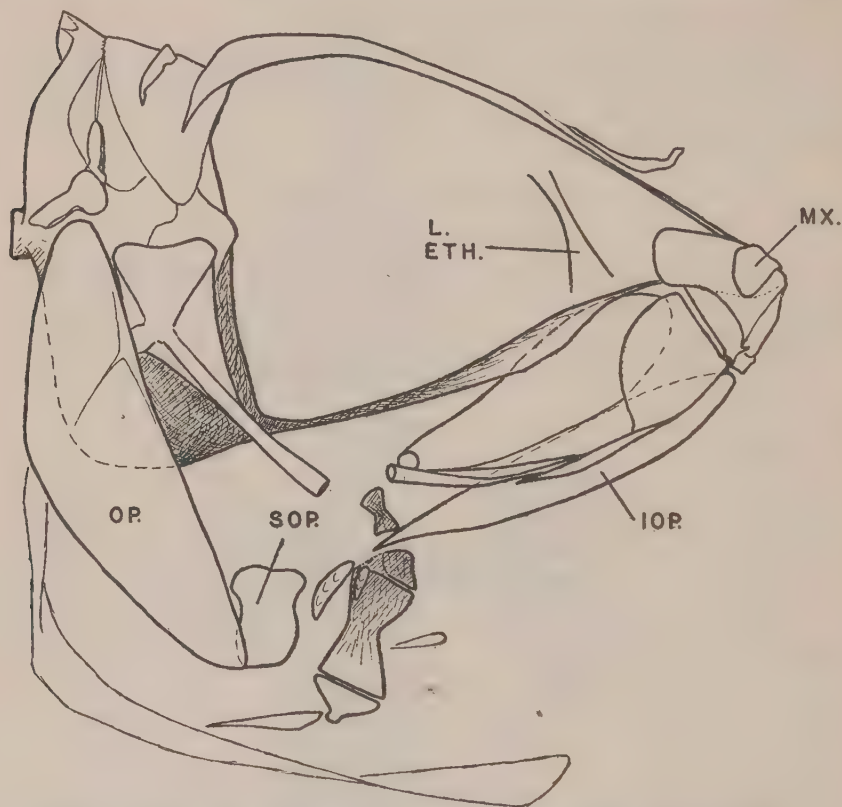


Figure 10. Lateral view of head skeleton of *Opisthoproctus soleatus*, with cleithrum indicated. Circumorbital bones removed. For explanation of lettering see Fig. 9.

inite durability. We therefore have definite reason to assume a decrease in available vitamin D towards the depths of the ocean, and organisms living in these depths must have adjusted themselves to a lower level of supply of this calcification-promoting factor. The simplest adjustment would of course be an adjustment to do with a less extensive ossification, which would imply a lowered vitamin D requirement. This quite probably is the main explanation of the generally reduced ossification of deep-sea fish skeletons.

By this the writer does not mean to suggest that a normally teratologic-looking deep-sea fish, if reared in an environment of greater vitamin D supply would lose its rachitic features; since the evolution of a reduced vitamin D requirement does not imply a retention of the capacity to utilize a greater supply of this factor for normal development. In other words, the "rachitic" deep-sea environment naturally becomes the sanctuary and abode of the phylogenetic-

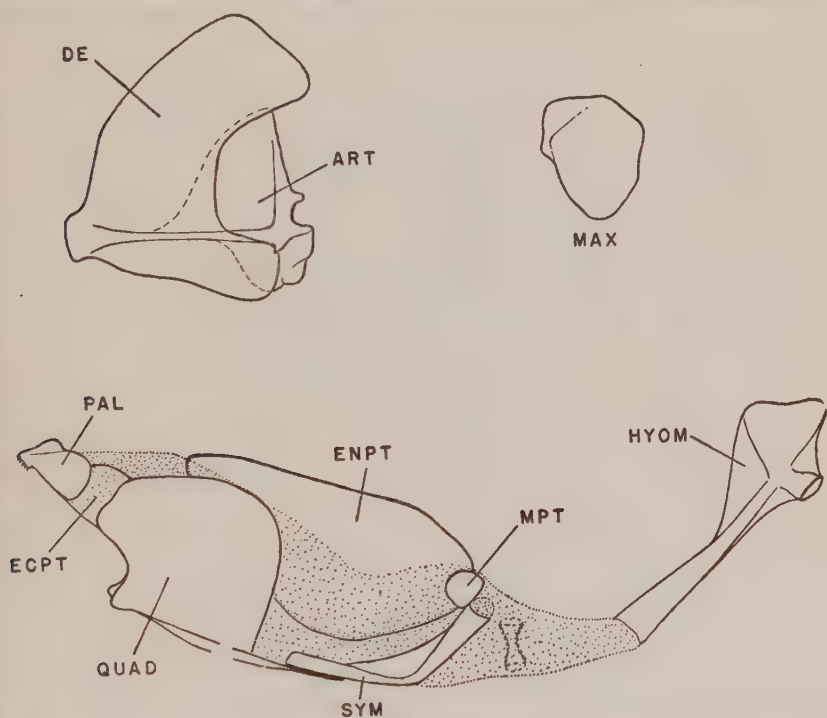


Figure 11. Jaws and suspensory of *Opisthoproctus soleatus*. For explanation of lettering see Fig. 9.

ally "rachitic" offshoots of evolution, in which their "normal abnormality" loses its disadvantages, and may indeed become a biological advantage through their ability to do without what other vertebrate forms of life require for their existence.

In arguing the genetic teratological character of *Opisthoproctus* Roule (1916, explicitly or implicitly reiterated by Roule, 1919 and Roule & Angel, 1933) has attempted to draw support for his contention by regarding it as an endemic teratological phenomenon of very restricted geographical occurrence. This consideration seems entirely inessential, the phenomenon being endemic to the

entire aphotic zone of all oceans, and the claim is only based upon the lack of previously available published records of the genus outside of the eastern Atlantic. Our material, of course, entirely disproves this claim, by indicating that the two species are no more uncommon in the West than in the East.

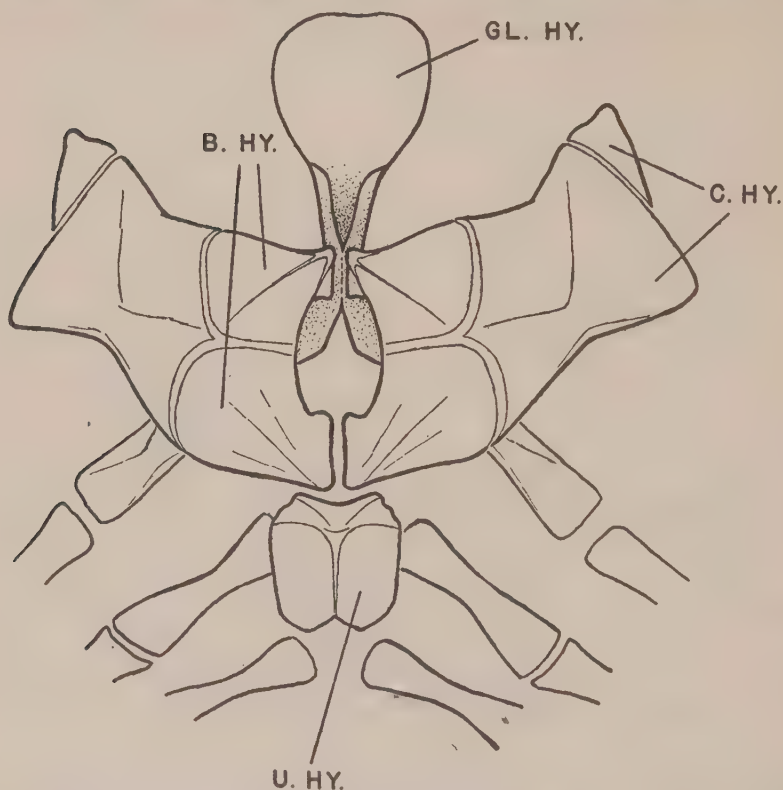


Figure 12. Thoracic skeleton of *Opisthoproctus soleatus*. For explanation of lettering see Fig. 9.

Already before the publication of Trewavas' excellent report on the anatomy of *Opisthoproctus*, the author had prepared a series of illustrations of its osteology. Since some of these illustrations present the anatomy in different views of perspectives from those selected by Trewavas, they may serve to supplement her figures for greater clarification of some of the details.

On two points the author has been able to observe additional skeletal structures, not recorded by Trewavas. Trewavas reports maxillaries and premaxillaries absent. While premaxillaries seem to be lacking even in the best pre-

served specimens, minute maxillaries almost in the form of a thin, somewhat sculptured scale, only, are normally present as shown in our figures 9-11; and in spite of their nudimentary condition they still retain traces of their normal form. These maxillaries, however, are so loosely connected with the skeleton and so prominently placed on the protruding snout that they are lost by abrasion in the nets etc. in about half of the specimens, which will explain their absence in Trewavas' example.



Figure 13. Caudal (incl. anal fin) skeleton of *Optisthoproctus soleatus*.

Secondly, it was possible to see a tiny, almost circular, very weakly ossified plate in the pterygoid arch near the upper end of the symplectic, situated on the outer side of the cartilage (away from the oral cavity) which undoubtedly represents the metapterygoid. This would then make the large bony plate on the adoral side of the cartilage, questioningly designated by Trewavas as "(metapterygoid?)", the actual entopterygoid, which is also in accordance with its position.

Incidentally, it might be pointed out that these large entopterygoids almost

meet in the median and are so firmly connected with each other and with the parasphenoid by means of fibrous connective tissues as to form a singularly rigid roof over the oral cavity, this roof being in fact the mechanically strongest and most rigid unit in the entire head skeleton.

Finally, Trewavas' extremely interesting discovery of a ventral swim-bladder in *Opisthoproctus* may give occasion for some comments on the functioning of swim-bladders in a deep-sea environment in the light of thermodynamics.

The energy required for the release of a free gas in the swim-bladder may be determined from the energy of compression formula:¹

$$E = RT \cdot \log_n \frac{P_2}{P_1}$$

R being the gas constant, T the absolute temperature and $\frac{P_2}{P_1}$ the ratio of (partial) pressures. Since gasses in the deep sea are only present in the order of magnitude of equilibrium with the air at 1 atmosphere, P_1 can be set = 1. Since free gas in a swim-bladder would have to assume the hydrostatic pressure of the environment P_2 can be set like the hydrostatic pressure. At 1000 meters depth the hydrostatic pressure is approximately 100 atmospheres. At 1000 meters' depth our equation is therefore:

$$E = RT \cdot \log_n \frac{100}{1}$$

or since

$$\begin{aligned} \log_n 100 &= 4.6 \\ E &= 4.6 RT. \end{aligned}$$

That is, while release of gasses in the swim-bladder of atmospheric composition at the surface requires no expenditure of energy ($\log_n \frac{1}{1} = 0$), and at 10 meters depth (2 atmospheres) requires only 0.7 RT ($\log_n 2 = 0.7$), the release of gas at 1000 meters depth requires about $6\frac{1}{2}$ times as much energy *Per unit weight* as at only 10 meters depth. Since furthermore the gas in 1000 meters depth, at 100 atmospheres pressure would have only 1/50 of the *volume* and buoyancy value per unit weight of the same gas at 10 meters (2 atmospheres) this figure ($6\frac{1}{2}$) must be multiplied by 50 to give us the energy requirement per unit buoyancy value. In other words, other things being equal, more than 300 times as much energy than in 10 meters depth must be spent in 1000 meters depth per unit buoyancy obtained. For this reason it is obvious that the use of the swim-bladder becomes increasingly uneconomical with increasing depth, and the author is strongly inclined to question whether a swim-bladder, even when morphologically present, is actually functioning except when the fish may be moving at high levels near the surface.

¹ The writer is indebted to Dr. Ancel B. Keys, of Harvard University for advice on this point.

Opisthoproctus soleatus Vaillant

- 2 specimens, No. 2723 B. O. C. Station 5, Feb. 26, 1927. 25° 56' N. 77° 37' W. 5000 feet wire.
2 specimens, No. 2724 B. O. C. Station 7, February 28, 1927. 24° 00' N. 77° 17' W. 6000 feet wire.
1 specimen, No. 2721 B. O. C. Station 9, March 1, 1927. 23° 55' N. 77° 09' W. 4000-7000 feet wire.
2 specimens, No. 2719 B. O. C. Station 23, March 14, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.
1 specimen, No. 2477 B. O. C. Station 25, March 17, 1927. 24° 51' N. 76° 38' W. 8000 feet wire.
1 specimen, No. 2722 B. O. C. Station 43, March 31, 1927. 22° 13' N. 74° 19' W. 4000 feet wire.

Opisthoproctus grimaldi Zugmayer

- 1 specimen, No. 3758 B. O. C. Station 48, April 6, 1927. N. 21° 44'. W. 72° 43'. 7000 feet wire.
1 specimen, No. 3757 B. O. C. Station 56, April 13, 1927. N. 21° 20'. W. 71° 13'. 6500 feet wire.

Family **DOLICHOPTERYGIDAE**Genus **Dolichopteryx** Brauer 1901

Norman (1930, p. 271) expressed the belief that all the specimens of *Dolichopteryx* previously described or available in his material should belong to one single species, while Roule and Angel (1930, pp. 69-76), in an account published in the same year, maintain the distinction between *D. longipes* (Vaillant) and *D. anascopa* Brauer. On the basis of the material in the Bingham Oceanographic Collection, there can be absolutely no doubt about the existence of at least two distinct species, which with consideration of previously published accounts can probably be increased to four. The author takes this as a confirmation of Roule and Angel's point of view and accepts both *D. longipes* (Vaillant) and *D. anascopa* Brauer as valid species.

Of the various forms *D. longipes* gives the least difficulties. Of this species the Bingham Collections contains several samples in perfect state of preservation showing that the pectoral fins are actually short and only the ventrals produced.

In *D. anascopa* the pectoral fins are also produced, but Brauer's measurements of a very small specimen (35 mm.) indicates an agreement with *D. longipes* in the size of head (31 per cent of length).

D. binocularis Beebe (1933, p. 59) is figured and described as having greatly produced pectorals but moderate ventrals. It differs from *D. longipes* and *D. anascopa* in the much smaller head (20 per cent of length).

In *D. brachyrhynchus*, n. sp. both pectorals and head are short.

Material or records from specimens of comparable size are available for 3 of these 4 species, *D. longipes*, *D. binocularis* and *D. brachyrhynchus* all being known from specimens of adult size (80–95 mm.) in type material or subsequent collections. For comparison with the small type specimen of *D. anascopa*, the records of Roule and Angel (1930) and Beebe (1933) and our own material provide us with a series of measurements of *D. longipes* from 26 mm. length to adult size, which does not suggest any decrease in average relative length of head after attainment of the size of the type specimen of *D. anascopa*; even when the questionable large-headed forms recorded by Beebe are excluded from consideration. This comparison therefore suggests that *D. anascopa* can not have been a young of *D. binocularis* or *D. brachyrhynchus*, while it is distinct from *D. longipes* by direct comparison with specimens of its own size.

The validity of the 4 species mentioned so far thus seems well established. On the other hand, the author is far from being confident that more species should not have been designated.

Roule and Angel's specimen 58 mm. long (Roule and Angel, 1930, pp. 73–74, pl. IV, figs. 94–95) and Norman's material (Norman, 1930, p. 371, fig. 3) are probably identical with *D. binocularis* Beebe.

The presence of a bulb-shaped luminous organ on the ball of the eye itself is apparently a generic character and its exact position may be used for specific distinctions.

Key to the genus *Dolichopteryx*.

A. Head large, less than 4 in length without caudal.

1. Pectorals short, ventrals produced.....*D. longipes* (Vaillant).
2. Both pectorals and ventrals produced.....*D. anascopa* Brauer.

B. Head small, about 5 or less in length without caudal.

1. Pectorals long. Only 5 glandular luminous bodies in midventral series in advance of ventral fins. Eyes small, $5\frac{1}{2}$ in head, about 3.1 per cent of length without caudal.....*D. binocularis* Beebe.
D. longipes? Norman 1930, p. 271, fig. 3.
2. Pectorals short. About 7 luminous bodies in midventral series before ventral fins. Eyes larger, only $4\frac{1}{2}$ in head, about 4.7 per cent of length without caudal.....*D. brachyrhynchus*, n. sp.

Measurements of *Dolichopteryx*

		<i>D. longipes</i> B. O. C.			<i>D. brachyrhynchus</i>
Length without caudal		65 mm.	77 mm.	79 mm.	95 mm.
Head	Per cent of length without caudal	31%	31%	30%	21%
Eye		—	—	—	4.7%
Snout		14%	13.5%	15%	8.4%
Snout to D		75%	78%	78%	73%
Snout to V		68%	70%	71%	71%
Snout to A		81%	81%	82%	87%
Length P		13%	14%	14%	7.5%
Length V		38%	34%	36%	—
Greatest depth		12%	13%	13%	9%

Dolichopteryx longipes (Vaillant 1888)

Aulostoma? longipes Vaillant 1888 (fide Roule and Angel 1930).

Dolichopterygiella type *longipes* Roule and Angel 1930, p. 69, pl. IV, figs. 90-93 and 96-98.

Dolichopteryx longipes Beebe 1933, pp. 70-80, figs. 20-21, nec. Norman 1930, p. 201, fig. 3.

2 specimens, No. 2715 B. O. C. Station 5, February 26, 1927. N. 25° 55' 50". W. 77° 36' 45". 5000 feet wire.

4 specimens, No. 2714 B. O. C. Station 7, February 28, 1927. N. 24° 00' 15". W. 77° 16' 40". 6000 feet wire.

1 specimen, No. 2716 B. O. C. Station 18, April 10, 1927. N. 23° 42'. W. 76° 43'. 7000 feet wire.

2 specimens, No. 2717 B. O. C. Station 23, April 14, 1927. N. 24° 29'. W. 77° 29'. 8000 feet wire.

Luminous organs on eye ball lateral opposite center of lens. For measurements see table above.

Beebe (1933, p. 77) records the proportions of an adult specimen as showing the head to be contained 2.4 times in the length without caudal (42.4 per cent), which would seem to suggest a separate, fifth species of the genus. The author is indebted to Dr. Beebe for an opportunity to examine the specimen in question and his measurements are rather at variance with those reported by Beebe. The specimen is severed in two about the middle, with portions at least of the musculature and the abdominal organs missing. The two parts barely hang together by a strand of very elastic (subdermal?) connective tissue. If we assume that the vertebral column is complete, the two fractions cannot add up to less than 91-91.5 mm. without caudal, as compared with 85 mm. recorded by Beebe. The author is further not at all convinced that the vertebral column



Figure 14. *Dolichopteryx longipes* (Vallant). Drawn by W. S. Bronson.

actually is complete, and considers it possible that the true length without caudal may have been more than 95 mm. This, by the writer's measurements, brings the relative length of the head down to a questionable 36-39 per cent, the record being without reliable significance.

Dolichopteryx brachyrhynchus, new species

1 specimen, No. 2718 B. O. C. TYPE. Station 31, April 23, 1927. N. 24° 29'. W. 75° 53'. 7000 feet wire.

The measurements of the specimen are given in the table, page 35. Although it is in a poor condition, it is not so damaged as to destroy or distort any essential measurable character except the length of the ventral fins. The pectorals, on the other hand, show the fin-rays complete, with the fibrous spatulate taper of the bifurcated distal portions.

D. 13. A. 12. P. 13. V. 8. About 70 myomeres.

Snout broad and short. Small teeth in a row in each jaw. Eyes semi-telescopic, broader than high but with protruding lenses.

Luminous organ on bulb of eye in front of the lens; directed sideways and slightly downward.

The abdomen, unfortunately, is badly torn, but the specimen indicates the presence of at least 6, possibly 7, apparently single median luminous organs in advance of anal fin, plus an apparent pair (single median torn?) below the pectorals. These organs are wart-like with a black tissue sheath on the sides on a greyish opaque central core. Microsections, although not very satisfactory, rather definitely indicate that they are secretory, probably luminous, glands. Between ventrals and anal fin similar organs occur in pairs, two organs on each side. In the median dorsal line there are 4 elongate, equally spaced patches of dark tissue in front of dorsal fin which are apparently more than mere pigment spots (luminous?). A similar spot on each side of the base of dorsal fin and two median spots, of which at least one seems definitely identical with the abdominal organs, between dorsal and caudal. A flat darkish spot is found above the base of anal fin on each side.

The type specimen is a mature male.

Family **BATHYLAGIDAE**

Genus **Bathylagus** Günther

The form variously described by Borodin (1929 and 1931) as "*Scopelus*" *bericoides* and "*Melamphaes*" *bericoides* has proved upon examination to be an apparently new species of *Bathylagus*, thereby unfortunately rendering Norman's excellent key to this genus (Norman 1930, p. 272) incomplete. Another specimen of Borodin's species is found in the collections here reported upon, and a figure and emended description is given herewith to correct the confusion caused by the previous erroneous classifications of the species.

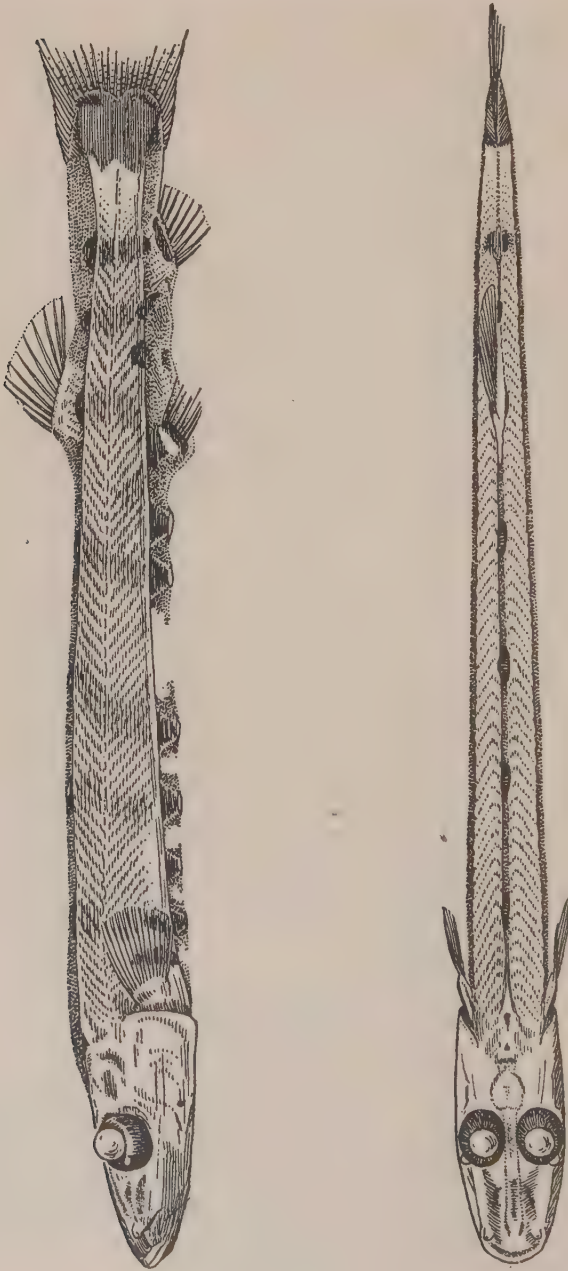


Figure 15. *Dolichopteryx brachyhynchus* n. sp. Drawn by W. S. Bronson.

In Norman's key *Bathylagus bericoides* (Borodin) would agree entirely with *B. microcephalus* (eye $2\frac{2}{3}$ in head, head nearly $5\frac{1}{2}$ in length).

B. bericoides differs from *B. microcephalus*, however, in having a significantly lower number of anal fin rays ($16\frac{1}{2}$ – $17\frac{1}{2}$ as compared with 20–22) and a shorter relative length of the anal fin base ($6\frac{1}{2}$ – $6\frac{2}{3}$, as compared with 5– $5\frac{2}{3}$ times in length without caudal).

***Bathylagus bericoides* (Borodin 1929)**

Scopelus bericoides Borodin 1929, p. 110.

Melamphaes bericoides Borodin 1931, p. 79.

1 specimen, No. 3750 B. O. C. Station 25, March 17, 1927. $24^{\circ} 51' N.$
 $76^{\circ} 37' 30'' W.$ 8000 feet wire.

Table of Measurements

		M. C. Z. No. 32315 TYPE	No. 31627	B. O. C. No. 3750
Length without caudal		161 mm.		156 mm.
Head	Per cent of length without caudal	18%	18%	18%
Eye		6.8%	7.0%	7.2%
Interocular width ¹		7.1%	—	7.1%
Interorbital width ²		2.3%	—	—
Greatest depth		15.5%	15.7%	15.0%
Depth of caudal peduncle		5.6%	—	5.8%
Snout to D		45.3%	43.5%	44.0%
Snout to V		50.3%	51.0%	51.0%
Snout to A		77%	75%	77%
Anal fin base		15.5%	—	15.0%
Dorsal fin rays		$10\frac{1}{2}$ ³	—	$10\frac{1}{2}$
Anal fin rays		$17\frac{1}{2}$	—	$16\frac{1}{2}$
Ventral fin rays		10	—	11 ⁴
Pectoral fin rays				11
Scales in lateral line		ab. 44		ab. 43

Snout square, almost perpendicular. Cross section of head and trunk more or less rectangular with flat ventral surface.

The scales are lost from the specimens but, judging by the scale pockets the number seems to be doubled in the lateral line, there being only about 25 large scale pockets in a longitudinal series above or below.

¹ Soft tissues.

² Bone.

³ Two last rays arising from single base counted as $1\frac{1}{2}$.

⁴ The upper ray only short stub.

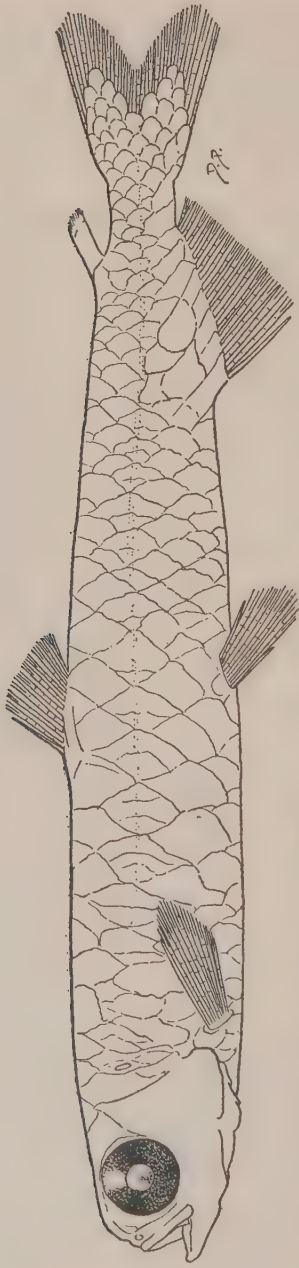


Figure 16. *Bathylagus bericoides* (Borodin). Drawn by D. T. Pitcher.

As in the genus *Bathylagus* in general, the species is otherwise free from descriptive features which are not expressed in its measurements and counts.

***Bathylagus euryops* Goode & Bean 1895**

- 2 specimens, B. O. C. No. 2670. Station 9.
- 2 specimens, B. O. C. No. 2671. Station 58.
- 1 specimen, B. O. C. No. 2672. Station 59.

Family **GONOSTOMATIDAE**

Genus **Gonostoma** Rafinesque

***Gonostoma elongatum* Günther 1878**

- 5 specimens, No. 2864 B. O. C. Station 5, February 26, 1927. 25° 56' N. 77° 37' W. 5000 feet wire.
- 3 specimens, No. 2865 B. O. C. Station 11, March 2, 1927. 23° 58' N. 77° 26' W. 7000 feet wire.
- 1 specimen, No. 2866 B. O. C. Station 23, March 14, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.
- 1 specimen, No. 2867 B. O. C. Station 25, March 17, 1927. 24° 51' N. 76° 37' W. 8000 feet wire.
- 8 specimens, No. 2868 B. O. C. Station 27, March 18, 1927. 24° 45' N. 76° 21' W. 8000 feet wire.
- 1 specimen, No. 2869 B. O. C. Station B. O. C. Station 31, March 21, 1927. 24° 29' N. 75° 53' W. 7000 feet wire.
- 1 specimen, No. 2870 B. O. C. Station 39, March 29, 1927. 22° 43' N. 74° 23' W. 8000 feet wire.
- 1 specimen, No. 2871 B. O. C. Station 41, March 30, 1927. 22° 31' N. 74° 26' W. 10,000 feet wire.
- 2 specimens, No. 2872 B. O. C. Station 52, April 11, 1927. 21° 30' N. 71° 11' W. 8000 feet wire.

***Gonostoma bathyphilum* (Vaillant 1884)**

- 1 specimen, No. 2861 B. O. C. Station 25, 17/3, 1927. 24° 51' N. 76° 37' 30". 8000 feet wire.
- 2 specimens, No. 2858 B. O. C. Station 33, 22/3, 1927. 24° 10' 40" N. 75° 36' 40" W. 8000 feet wire.
- 1 specimen, No. 2860 B. O. C. Station 41, 30/3, 1927. 22° 31' 15" N. 74° 26' 20" W. 10,000 feet wire.
- 1 specimen, No. 2859 B. O. C. Station 46, 4/4/, 1927. 21° 46' 12" N. 72° 49' 30" W. 10,000 feet wire.

The great variability in the arrangement of the upper series of photophores is shown in the accompanying diagrammatic illustration of their distribution on

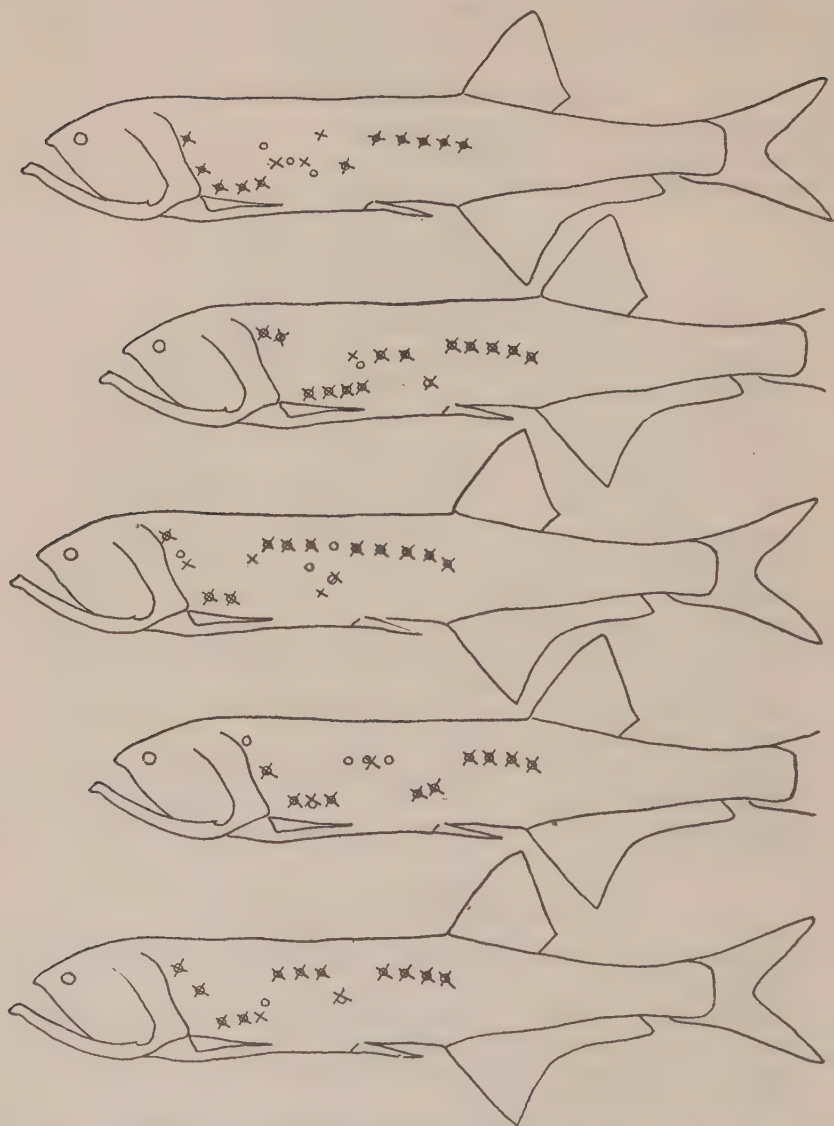


Figure 17. Variations in photophore arrangements in 5 specimens of *Gonostoma bathyphilum*. x = right side. o = left side.

the two sides of each of the specimens here reported upon. No taxonomic significance could be discovered in these variations of pattern since they do not seem correlated with consistent variations in any other morphological feature. Norman (1930, p. 285) records only 3 photophores in the lower series from pelvics to the origin of anal fin; Zugmayer (1911, p. 49) records 3-4 organs in this position; and the specimens on hand all have 4. The possibility of taxonomic distinctions based upon this feature might perhaps be worth investigating. One of the specimens has 4 teeth on the vomer, 2 on each side symmetrically arranged.

Genus **Cyclothone** Goode and Bean

For the differentiation of *c. pallida* and *c. microdon* see Parr (1934b, p. 12).

Cyclothone pallida, Brauer

- 35 specimens + 18 questionable, No. 2968 B. O. C. Station 5, February 26, '27. N. 25° 56'. W. 77° 37'. 5000 feet wire.
- 30 specimens, No. 2969 B. O. C. Station 7, February 28, '27 N. 24° 00'. W. 77° 17', 6000 feet wire.
- 23 specimens No. 2970 B. O. C. Station 9, March 1, 1927. N. 23° 55' W. 77° 09', 4000-7000 feet wire.
- 22 specimens No. 2900 B. O. C. Station 11, March 2, 1927. N. 23° 58' W. 77° 26', 7000 feet wire.
- 40 specimens No. 2883 B. O. C. Station 16, March 9, 1927. N. 23° 49'. W. 76° 58', 7000 feet wire.
- 18 specimens No. 2896 B. O. C. Station 18, March 10, 1927. N. 23° 42'. W. 76° 43', 7000 feet wire.
- 5 specimens No. 2876 B. O. C. Station 22, March 12, 1927 N. 23° 37'. W. 77° 15', 7000 feet wire.
- 19 specimens No. 2972 B. O. C. Station 23, March 14, 1927. N. 24° 29'. W. 77° 29', 8000 feet wire.
- 9 specimens No. 2885 B. O. C. Station 25, March 17, 1927. N. 24° 51'. W. 76° 37', 8000 feet wire.
- 1 specimen questionable, No. 2897 B. O. C. Station 27, March 18, 1927. N. 20° 45'. W. 76° 21', 8000 feet wire.
- 2 specimens No. 2973 B. O. C. Station 31, Mar. 21, 1927. N. 24° 29'. W. 75° 53', 7000 feet wire.
- 8 specimens No. 2887 B. O. C. Station 33, March 22, 1927. N. 24° 11'. W. 75° 37', 8000 feet wire.
- 1 specimen, No. 2974 B. O. C. Station 35, March 23, 1927. N. 24° 11'. W. 75° 35', 7500 feet wire.
- 15 specimens, No. 2881 B. O. C. Station 39, March 29, 1927. N. 22° 43'. W. 74° 23', 8000 feet wire.

- 12 specimens, No. 2874 B. O. C. Station 41, March 30, 1927. N. $22^{\circ} 31'$.
W. $74^{\circ} 26'$, 10,000 feet wire.
- 1 specimen, No. 2878 B. O. C. Station 46, April 4, 1927. N. $21^{\circ} 46'$. W.
 $72^{\circ} 50'$, 10,000 feet wire.
- 36 specimens, No. 2889 B. O. C. Station 52, April 11, 1927. N. $21^{\circ} 30'$. W.
 $71^{\circ} 11'$, 8000 feet wire.
- 36 specimens, No. 2895 B. O. C. Station 56, April 13, 1927. N. $21^{\circ} 20'$. W.
 $71^{\circ} 13'$, 6500 feet wire.
- 2 specimens, No. 2891 B. O. C. Station 59, April 21, 1927. N. $32^{\circ} 19'$. W.
 $64^{\circ} 33'$, 8000 feet wire.

Cyclothone microdon Günther

- 9 specimens, No. 2977 B. O. C. Station 9, March 1, 1927. N. $23^{\circ} 55'$. W.
 $77^{\circ} 09'$, 4000-7000 feet wire.
- 86 specimens, No. 2898 B. O. C. Station 11, March 2, 1927. N. $23^{\circ} 58'$.
W. $77^{\circ} 26'$, 7000 feet wire.
- 53 specimens, No. 2882 B. O. C. Station 16, March 9, 1927. N. $23^{\circ} 49'$.
W. $76^{\circ} 58'$, 7000 feet wire.
- 80 specimens, No. 2892 B. O. C. Station 18, March 10, 1927. N. $23^{\circ} 42'$.
W. $76^{\circ} 43'$, 7000 feet wire.
- 35 specimens, No. 2875 B. O. C. Station 22, March 12, 1927. N. $23^{\circ} 37'$.
W. $77^{\circ} 15'$, 7000 feet wire.
- 96 specimens, No. 2976 B. O. C. Station 23, March 14, 1927. N. $24^{\circ} 29'$.
W. $77^{\circ} 29'$, 8000 feet wire.
- 78 specimens, No. 2884 B. O. C. Station 25, March 17, 1927. N. $24^{\circ} 51'$.
W. $76^{\circ} 37'$, 8000 feet wire.
- 46 specimens questionable, No. 2893 B. O. C. Station 27, March 18, 1927.
N. $20^{\circ} 45'$. W. $76^{\circ} 21'$, 8000 feet wire.
- 47 specimens, No. 2975 B. O. C. Station 31, March 21, 1927. N. $24^{\circ} 29'$.
W. $75^{\circ} 53'$, 7000 feet wire.
- 79 specimens, No. 2886 B. O. C. Station 33, March 22, 1927. N. $24^{\circ} 11'$.
W. $75^{\circ} 37'$, 8000 feet wire.
- 7 specimens, No. 2978 B. O. C. Station 35, March 23, 1927. N. $24^{\circ} 11'$.
W. $75^{\circ} 35'$, 7500 feet wire.
- 123 specimens, No. 2880 B. O. C. Station 39, March 29, 1927. N. $22^{\circ} 43'$.
W. $74^{\circ} 23'$, 8000 feet wire.
- 123 specimens, No. 2873 B. O. C. Station 41, March 30, 1927. N. $22^{\circ} 31'$.
W. $74^{\circ} 26'$, 10,000 feet wire.
- 23 specimens, No. 2877 B. O. C. Station 46, April 4, 1927. N. $21^{\circ} 46'$. W.
 $72^{\circ} 50'$, 10,000 feet wire.
- 28 specimens, No. 2888 B. O. C. Station 52, April 11, 1927. N. $21^{\circ} 30'$.
W. $71^{\circ} 11'$, 8,000 feet wire.

- 35 specimens, No. 2894 B. O. C. Station 56, April 13, 1927. N. $21^{\circ} 20'$. W. $71^{\circ} 13'$, 6500 feet wire.
77 specimens, No. 2879 B. O. C. Station 58, April 20, 1927. N. $32^{\circ} 24'$. W. $64^{\circ} 29'$, 10,000 feet wire.
44 specimens, No. 2890 B. O. C. Station 59, April 21, 1927. N. $32^{\circ} 19'$. W. $64^{\circ} 33'$, 8000 feet wire.

Cyclothone braueri Jespersen & Taning

- 57 specimens, No. 2979 B. O. C. Station 5, February 26, 1927. N. $25^{\circ} 56'$. W. $77^{\circ} 37'$, 5000 feet wire.
3 specimens, No. 2982 B. O. C. Station 7, February 28, 1927. N. $24^{\circ} 00'$. W. $77^{\circ} 17'$, 6000 feet wire.
1 specimen, No. 2980 B. O. C. Station 9, March 1, 1927. N. $23^{\circ} 55'$. W. $77^{\circ} 09'$, 4000–7000 feet wire.
5 specimens, No. 2983 B. O. C. Station 16, March 9, 1927. N. $23^{\circ} 49'$. W. $76^{\circ} 58'$, 7000 feet wire.
2 specimens, No. 2981 B. O. C. Station 46, April 4, 1927. N. $21^{\circ} 46'$. W. $72^{\circ} 50'$, 10,000 feet wire.
93 specimens, No. 2985 B. O. C. Station 58, April 20, 1927. N. $32^{\circ} 24'$. W. $64^{\circ} 29'$, 5000 feet wire.
9 specimens, No. 2984 B. O. C. Station 59, April 21, 1927. N. $32^{\circ} 19'$. W. $64^{\circ} 33'$, 3000 feet wire.

Genus **Yarrella** Goode and Bean

Yarrella blackfordi Goode and Bean

- 5 specimens, No. 2947 B. O. C. Station 5, February 26, 1927. $25^{\circ} 56'$ N. $77^{\circ} 37'$ W. 5000 feet wire.
1 specimen, No. 2951 B. O. C. Station 9, March 1, 1927. $23^{\circ} 55'$ N. $77^{\circ} 09'$ W. 4000–7000 feet wire.
1 specimen, No. 2948 B. O. C. Station 16, March 9, 1927. $23^{\circ} 49'$ N. $76^{\circ} 58'$ W. 7000 feet wire.
1 specimen, No. 2942 B. O. C. Station 18, March 10, 1927. $23^{\circ} 42'$ N. $76^{\circ} 43'$ W. 7000 feet wire.
2 specimens, No. 2949 B. O. C. Station 25, March 17, 1927. $24^{\circ} 51'$ N. $76^{\circ} 37'$ W. 8000 feet wire.
1 specimen, No. 2946 B. O. C. Station 31, March 21, 1927. $24^{\circ} 29'$ N. $75^{\circ} 53'$ W. 7000 feet wire.
1 specimen, No. 2944 B. O. C. Station 46, April 4, 1927. $21^{\circ} 46'$ N. $72^{\circ} 50'$ W. 10,000 feet wire.
3 specimens, No. 2945 B. O. C. Station 47, April 5, 1927. $21^{\circ} 44'$ N. $72^{\circ} 41'$ W. 3500 feet wire.

1 specimen, No. 2943 B. O. C. Station 48, April 6, 1927. 21° 44' N. 72° 43' W. 7000 feet wire.

1 specimen, No. 2950 B. O. C. Station 56, April 13, 1927. 21° 20' N. 71° 13' W. 6500 feet wire.

Genus **Diplophos** Günther

Diplophos minutus Jespersen and Taning

1 specimen, No. 2689 B. O. C. Station 23, March 14, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.

Family **STERNOPTYCHIDAE**

Genus **Argyropelecus** Cocco

In a previous publication (Parr 1931 *a*, p. 17, fig. 5) the writer has tentatively retained *A. lychnus* Garman as a distinct species from *A. olfersii* Cuvier with which it has been synonymized by Norman (1930, p. 304) and has described and figured in detail its abdominal spines which are perhaps of greater taxonomic importance than heretofore recognized. In the material here reported upon 3 further species have been available for study and a fourth (*A. sladeni* Norman) has been received in exchange from the British Museum. In the accompanying illustration camera lucida drawings of the abdominal spines of all the 5 species so far investigated are presented together for comparison. Since the author has not as yet had opportunity to examine any specimens of *A. olfersii*, he has nothing to add to his previous discussion of its relationship to *A. lychnus* but includes an outline of its abdominal spines as shown in Norman's figure of this species (Norman 1930, fig. 12, p. 304). A comparison with the drawing of the abdominal spines in *A. lychnus* speaks for itself.

From figure 19 it will be noticed that the difference between the abdominal spines of *A. sladeni* Norman and *A. lychnus* Garman is very slight. On the other hand, the difference between *A. sladeni* and *A. olfersii* in regard to body depth already mentioned by Norman also holds in a comparison with *A. lychnus*. A more distinct numerical expression for this difference between *A. lychnus* and *A. sladeni* would seem to be found in the relative depths of the cheeks, measured from the lower margin of the eye to the lower preopercular edge (running forward from the base of the upper preopercular spine). In *A. sladeni* the depth of the cheeks thus measured is only about 19–21 per cent of the length without caudal; in *A. lychnus* 23–26 per cent. If Norman's figure of *A. olfersii* (Norman 1930, fig. 12, p. 304) is accurate in this respect *A. olfersii* and *A. sladeni* would, on the other hand, appear to be indistinguishable with regard to depth of cheek. Another numerical expression can also be obtained from the distance between the top of the transparent area in the last abdominal photophore and the top of the transparent area in the first postabdominal photophore. In *A. sladeni*

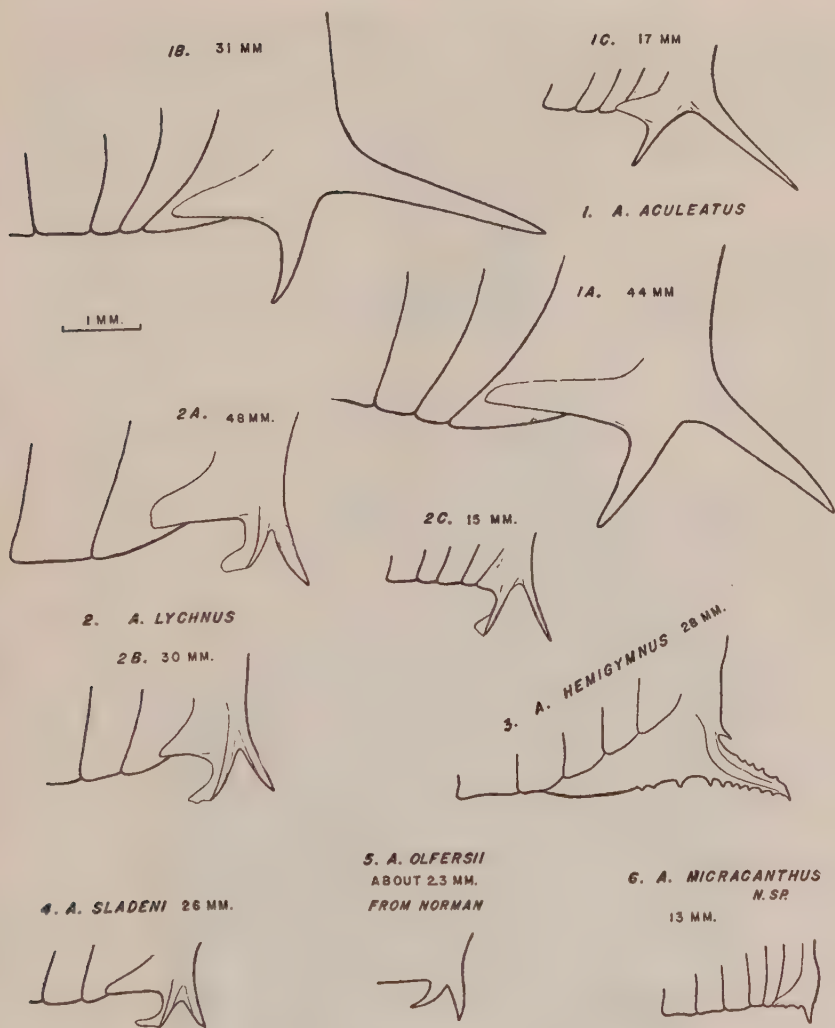


Figure 18. Abdominal spines in *Argyropelecus aculeatus* (1 A-1 C), *A. lychnus* (2 A-2 C), *A. hemigymnus* (3), *A. sladeni* (4), *A. olfersii*, from Norman 1930, fig. 12 (5), and *A. micracanthus* n. sp. (6).

(26 mm.) this distance is only 16.5 per cent of the length without caudal. In *A. lychnus* (30 mm.) 21.5 per cent. Norman's figure shows about 19-20 per cent in *A. olfersii*.

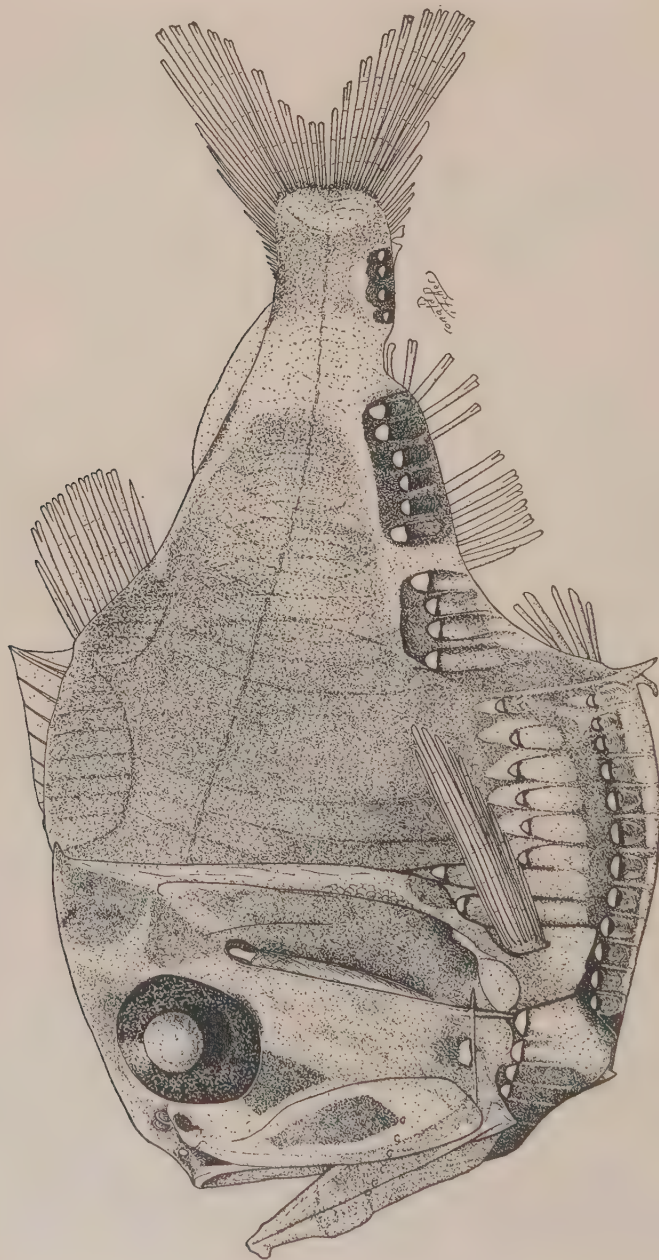


Figure 19. *Argyropelecus sladeni*. 26 mm. without caudal fin. Drawn by D. T. Pitcher.

From figure 19 it will be seen at once that it is possible to make some very sharp distinctions within the genus *Argyropelecus* on the basis of the abdominal spines and the posterior abdominal scutes alone. Since a new species is also being introduced herewith, and an old species tentatively reclaimed from synonymy, a modification and expansion of Norman's key to the genus *Argyropelecus* (Norman 1930, p. 301¹) seems desirable:

- I. "Photophores forming a nearly continuous series."*
 - A. "Depth of body (without dorsal ridge) $2\frac{1}{4}$ to $2\frac{1}{3}$ in the length; praedorsal ridge rather low, length of exposed portion of last spine more than twice in the base of the dorsal fin."* . . . *affinis*, Garman, 1899
 - B. "Depth of body (without dorsal ridge) $1\frac{1}{2}$ to nearly 2 in the length; praedorsal ridge higher, length of exposed portion of last spine $1\frac{3}{4}$ to $1\frac{1}{2}$ in the base of the dorsal fin."* *gigas*, n. sp.
- II. "Postabdominal photophores in three groups (prae-anal, supra-anal, and caudal)."*
 - A. A single serrated abdominal spine, directed backwards with anterior extension of base covering $3\frac{1}{2}$ scutes. A conspicuous posterior spur above spine, sometimes developed into a secondary spine. "Supra-anal photophores separated from prae-anals by a distance of more than half the length of the supra-anal series, and from the caudal by a distance which is less than the length of the supra-anal series."*
hemigymnus, Cocco, 1829.
 - B. A single small abdominal spine, directed downwards.
 1. Postabdominal photophores in 3 widely separated groups, distance between pre-anal and supra-anal group about equal to and distance between supra-anal and pre-caudal group more than twice as long as supra-anal series. Only 5 supra-anal organs.
A. micracanthus, n. sp.
 2. Pre-anal and supra-anal organs only narrowly separated (about the width of a single organ or less¹). Distance from supra-anals to pre-caudals less than length of supra-anal group. 6 supra-anals. Abdomen serrate. Infracaudal spines present.
A. amabilis (Ogilby).²
?A. caninus Garman 1899, p. 235.
 - C. A pair of smooth abdominal spines, the forward extension of their base barely reaching second scute in advance or less. "Supra-anal photophores separated from the prae-anals by a very short interspace, and from the caudals by a distance which is less than the length of the supra-anal series."*

¹ Quotations marked by asterisk in the following key are taken from Norman's synopsis.

² fide McCulloch 1923, p. 118 and pl. XIV, fig. 3.

1. Posterior abdominal spine longer than the anterior and directed backwards. Anterior spine without lamina. Forward extension of base nearly or entirely overlapping first scute in advance. Second and third scutes in advance of spines conspicuously narrowed and curved forward. Spines much larger than in 2. "Adults with the dorsal and abdominal ridges serrated, and with a double series of spines on the lower edge of the caudal peduncle."*.....*aculeatus*, Cuv. and Val., 1850.
2. Abdominal spines subequal, or anterior spine longer. Posterior spine directed downwards. Anterior spine with an anterior bony flag-like lamina near its tip. Forward extension of base not nearly covering first scute in advance. Second and third scute in advance of normal width. Dorsal and abdominal ridges not serrated. No spines on caudal peduncle.
 - a. Lower preopercular spine curved. Posterior abdominal spine slightly curved forward (?).* Interspace between caudal and supra-anal photophores greater than length of caudal series (?).*.....*A. olfersii* (Cuvier).
 - b. Lower preopercular spine straight. Posterior abdominal spine slightly curved backwards. Interspace between caudal and supra-anal photophores conspicuously shorter than caudal series.
 - x. Depth of body about $1\frac{3}{5}$ or more in length. Lower preopercular edge (lower base of upper preopercular spine) to lower margin of orbit about 19–21 per cent of total length without caudal. Distance between upper margins of last abdominal and first postabdominal photophore only about 16–17 per cent of length (26 mm.).....*A. sladeni* Norman 1930.
 - xx. Depth of body about $1\frac{1}{2}$ in length. Lower preopercular edge to lower margin or orbit about 23–26 per cent of total length without caudal. Distance between upper margins of last abdominal and first postabdominal photophore about 21–22 per cent of length (30 mm.).....*A. lychnus* Garman 1899.

* fide Norman 1930, fig. 12, p. 304.

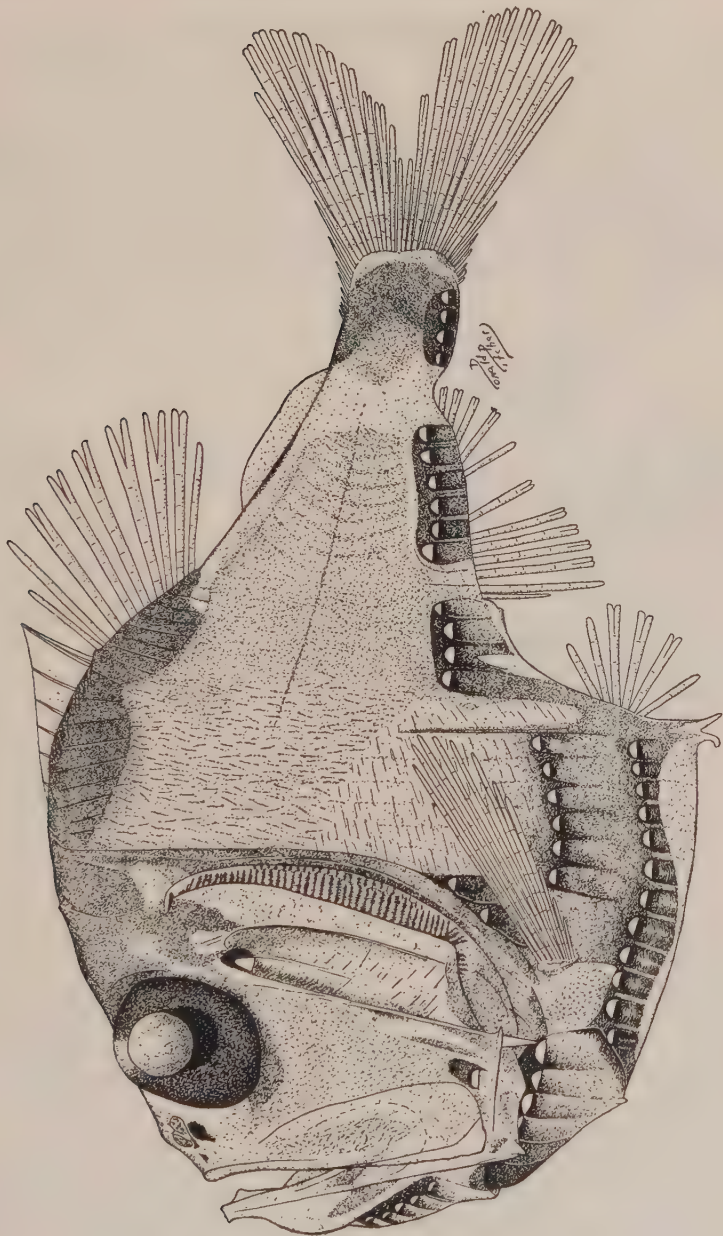


Figure 20. *Argyropelecus lychnus*. 30 mm. without caudal fin. Drawn by D. T. Pitcher.

***Argyropelecus micracanthus*, new species**

1 specimen, TYPE No. 3768 B. O. C. Station 16, March 9, 1927. 23° 49' N. 76° 58' W. 7000 feet wire.

Since the specimen above recorded cannot be identified with any previously described species, it seems necessary to describe it as a new form, although the author regrets this necessity so long as only one small specimen is available.

Length without caudal fin 13 mm. Proportions in per cent of length without caudal (taken from exact camera lucida drawing, fig. 21). Horizontal length of

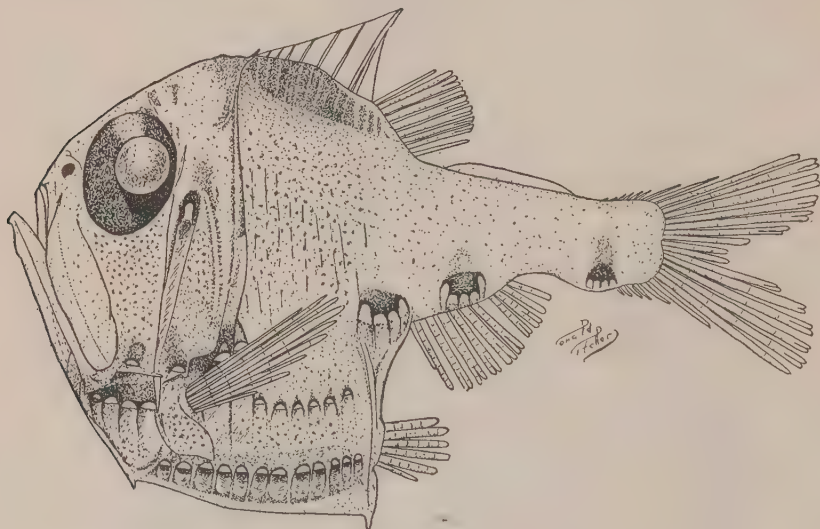


Figure 21. *Argyropelecus micracanthus* n. sp. Drawn by D. T. Pitcher.

head 33 per cent. Greatest depth 72 per cent. Depth between posterior end of dorsal and anterior end of anal fin about 26-27 per cent. Least depth of caudal fin $12\frac{1}{2}$ per cent. Vertical diameter of eye 20 per cent. Horizontal diameter of eye 14 per cent. Depth of cheek 19-20 per cent. Length of lower jaw 32 per cent. Distance from clavicular spine to posterior abdominal spine 39 per cent. Upper margin of last abdominal to upper margin of first postabdominal photophore 23.3 per cent.

Roule and Angel (1933) give an illustration of *A. olfersii* (loc. cit., pl. II, fig. 24) showing only one single abdominal spine, slightly curved forward, in a manner resembling the conditions found in our specimen of *A. micracanthus*. These authors are apparently unaware of Norman's report which is not listed in their bibliography, and the identity of their material seems questionable.

If the illustration is accurate, their specimen may be another representative of *A. micracanthus*.

The arrangement of the photophores will be seen from fig. 20, drawn with the aid of a camera lucida. The presence of only 5, instead of 6, supra-anal photophores is a notable feature distinguishing this species from all others of the genus. The wide separations between the postabdominal groups might possibly change with further growth, but comparison with examples of the same size in other species does not suggest the probability of a complete obliteration of the distinctive feature of the wide spacing. Dorsal and abdominal ridges are entirely smooth and there are no subcaudal spines. The forward extension of the base of the abdominal spine reaches to the second scute in advance.

***Argyropelecus aculeatus* Cuv. Val.**

- 1 specimen, No. 3752 B. O. C. Station 5, February 27, 1927. 25° 56' N. 77° 37' W. 5000 feet wire.
- 2 specimens, No. 3754 B. O. C. Station 27, March 18, 1927. 24° 45' 20'' N. 76° 20' 30'' W. 8000 feet wire.
- 1 specimen, No. 3753 B. O. C. Station 35, March 23, 1927. 24° 11' N. 75° 35' W. 7500 feet wire.
- 1 specimen, No. 3751 B. O. C. Station 56, April 13, 1927. 21° 20' N. 71° 13' W. 6500 feet wire.

***Argyropelecus hemigymnus*, Cooco**

- 4 specimens, No. 2995 B. O. C. Station 5, February 26, 1927. N. 25° 56'. W. 77° 37', 5000 feet wire.
- 4 specimens, No. 3005 B. O. C. Station 7, February 28, 1927. N. 24° 00'. W. 77° 17', 6000 feet wire.
- 5 specimens, No. 3002 B. O. C. Station 9, March 1, 1927. N. 23° 55'. W. 77° 09', 4000-7000 feet wire.
- 3 specimens, No. 2971 B. O. C. Station 11, March 2, 1927. N. 23° 58'. W. 77° 26', 7000 feet wire.
- 5 specimens, No. 2990 B. O. C. Station 16, March 9, 1927. N. 23° 49'. W. 76° 58', 7000 feet wire.
- 4 specimens, No. 2999 B. O. C. Station 18, March 10, 1927. N. 23° 42'. W. 76° 43', 7000 feet wire.
- 3 specimens, No. 3000 B. O. C. Station 22, March 12, 1927. N. 23° 37'. W. 77° 15', 7000 feet wire.
- 5 specimens, No. 2998 B. O. C. Station 23, March 14, 1927. N. 24° 29'. W. 77° 29', 8000 feet wire.
- 5 specimens, No. 2993 B. O. C. Station 25, March 17, 1927. N. 24° 51'. W. 76° 37', 8000 feet wire.

- 7 specimens, No. 3006 B. O. C. Station 31, March 21, 1927. N. $24^{\circ} 29'$. W. $75^{\circ} 53'$, 7000 feet wire.
- 3 specimens, No. 2988 B. O. C. Station 33, March 22, 1927. N. $24^{\circ} 11'$. W. $75^{\circ} 37'$, 8000 feet wire.
- 1 specimen, No. 2992 B. O. C. Station 35, March 23, 1927. N. $24^{\circ} 11'$. W. $75^{\circ} 35'$, 7000 feet wire.
- 2 specimens, No. 3007 B. O. C. Station 39, March 29, 1927. N. $22^{\circ} 43'$. W. $74^{\circ} 23'$, 8000 feet wire.
- 5 specimens, No. 2994 B. O. C. Station 43, March 31, 1927. N. $22^{\circ} 12' 15''$. W. $74^{\circ} 19'$, 4000 feet wire.
- 5 specimens, No. 2991 B. O. C. Station 46, April 4, 1927. N. $21^{\circ} 46'$. W. $72^{\circ} 50'$, 10,000 feet wire.
- 1 specimen, No. 3004 B. O. C. Station 47, April 5, 1927. N. $21^{\circ} 43' 55''$. W. $72^{\circ} 41' 20''$, 3500 feet wire.
- 1 specimen, No. 2987 B. O. C. Station 48, April 6, 1927. N. $21^{\circ} 44'$. W. $72^{\circ} 43'$, 7000 feet wire.
- 8 specimens, No. 2989 B. O. C. Station 52, April 11, 1927. N. $21^{\circ} 30'$. W. $71^{\circ} 11'$, 8000 feet wire.
- 3 specimens, No. 2986 B. O. C. Station 56, April 13, 1927. N. $21^{\circ} 20'$. W. $71^{\circ} 13'$, 6500 feet wire.
- 3 specimens, No. 2997 B. O. C. Station 58, April 20, 1927. N. $32^{\circ} 24'$. W. $64^{\circ} 29'$, 5000 feet wire.
- 4 specimens, No. 3003 B. O. C. Station 58, April 20, 1927. N. $32^{\circ} 24'$. W. $64^{\circ} 29'$, 10,000 feet wire.
- 6 specimens, No. 2996 B. O. C. Station 59, April 21, 1927. N. $32^{\circ} 19'$. W. $64^{\circ} 33'$, 3000 feet wire.
- 3 specimens, No. 3001 B. O. C. Station 59, April 21, 1927. N. $32^{\circ} 19'$. W. $64^{\circ} 33'$, 8000 feet wire.

Genus *Polyipnus* Günther 1887

When introducing the new subgenus *Acanthopolyipnus* Fowler (1934, p. 257) apparently overlooks the fact that the genotype of *Polyipnus* (*P. spinosus* Gthr.) agrees with *Acanthopolyipnus* in the most conspicuous qualitative feature of its spinous armament, namely the presence of a pair of divergent lateral spines on the basal portion of each post-temporal spine.* On the basis of this character the genotypes of *Polyipnus* and *Acanthopolyipnus* are therefore more closely related to each other than to the other two species in this systematic group. The subdivision of the genus *Polyipnus* as proposed by Fowler would therefore be confusing unless carried to the logical point of 3 separate subgenera distinguished both by armament and luminous organs. Such subdivision seems entirely unnecessary and without any advantage.

* Similar agreement is also observed in one of the main features in the arrangement of the luminous organs. See key to species.

Key to the genus *Polyipnus*

- A. A pair of divergent lateral spines on the basal portion of each post-temporal spine. Postabdominal photophores in two groups only, without an intermediate group separately elevated high above the rest of the series.
1. Postabdominal organs confluent, with the second group, which contains 11-16 organs, beginning abruptly higher than the first group. Preopercular spine single, directed downwards. *P. spinosus* Günther 1887.
 2. The two groups of the postabdominal organs separated by a wide interspace. The second group containing only 4 small organs, not higher above the ventral profile than the organs of the first group. Preopercular corner with 2 spines, one directed backwards, one downwards. *P. fraseri* Fowler 1934.
- B. Post-temporal spine straight and simple. Postabdominal series with an intermediate group of 3 luminous organs separately elevated above the others. Preopercular corner with a single small downwards-directed spine. *P. laternatus* Garman

***Polyipnus laternatus* Garman 1899**

1 specimen, No. 3756 B. O. C. Station 52, April 11, 1927. 21° 30' N. 71° 11' W. 8000 feet wire.

1 specimen, No. 3755 B. O. C. Station 54, April 12, 1927. N. 21° 16'. W. 71° 17'. 7500 feet wire.

In his original description Garman (1899, p. 238) refers to figure 148, plate XXXIX in Goode and Bean (1895) for an illustration of his new species. It is obvious from the description that this illustration is very misleading in several respects, particularly with regard to the arrangement of the postabdominal photophores. It has later become supplanted by the figure given by Norman (1930, p. 305), but the writer has also found this illustration to be incomplete in so far as the posterior group of postabdominal photophores is concerned. Garman explicitly records 11 luminous organs "in the row at the side of the anal", plus 4 "in the subcaudal group" and 3 "above the space between the ventral [i. e. the anterior postabdominal group] and the anal series". Our specimens both have 12 organs in the posterior postabdominal series. Of these 11-12 posterior postabdominal photophores the last 3-4, which are small and probably easily abraded, are lacking in Norman's figure, which also shows the 3 suprapectoral photophores more equally spaced than in our specimens and in Garman's description, in which the lower 2 suprapectoral photophores are situated close together with the third, upper, organ separately high above. If these differences are real, and not only accidental, Norman's figure might refer to a new species. Since our specimens in any event agree entirely with the original description, a new figure showing the full complement of luminous organs is given herewith.

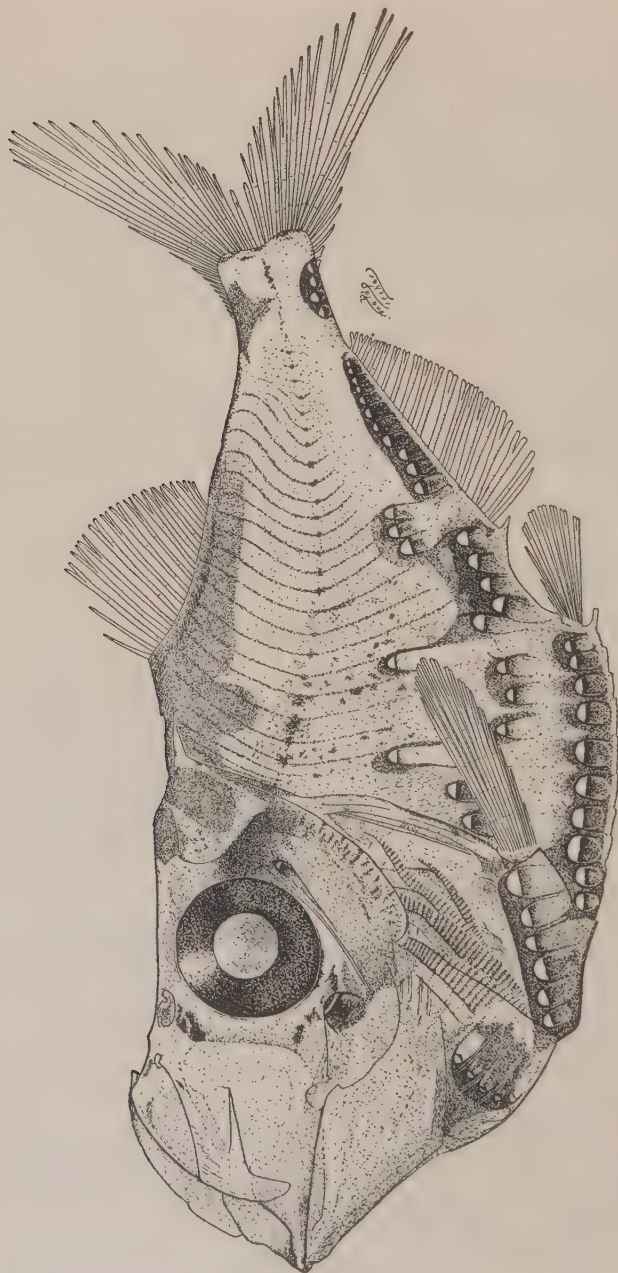


Figure 22. *Polyipnus laternatus*. Drawn by D. T. Pitcher.

Genus **Sternoptyx** Hermann**Sternoptyx diaphana** Hermann

- 2 specimens, No. 2789 B. O. C. Station 5, February 26, 1927. 25° 55' 50'' N. 77° 36' 45'' W. 5000 feet wire.
- 12 specimens, No. 2779 B. O. C. Station 7, February 28, 1927. 24° 00' N. 77° 17' W. 6000 feet wire.
- 30 specimens, No. 2777 B. O. C. Station 9, March 1, 1927. 23° 55' N. 77° 09' W. 4000-7000 feet wire.
- 40 specimens, No. 2794 B. O. C. Station 11, March 2, 1927. 23° 57' 45'' N. 77° 26' 25'' W. 7000 feet wire.
- 9 specimens, No. 2775 B. O. C. Station 16, March 9, 1927. 23° 49' 15'' N. 76° 58' 30'' W. 7000 feet wire.
- 7 specimens, No. 2901 B. O. C. Station 18, March 10, 1927. 23° 42' N. 76° 43' W. 7000 feet wire.
- 6 specimens, No. 2785 B. O. C. Station 22, March 12, 1927. 23° 37' 25'' N. 77° 15' 10'' W. 7000 feet wire.
- 21 specimens, No. 2792 B. O. C. Station 23, March 14, 1927. 24° 28' 35'' N. 77° 28' 30'' W. 8000 feet wire.
- 28 specimens, No. 2793 B. O. C. Station 25, March 17, 1927. 24° 51' N. 76° 37' 30'' W. 8000 feet wire.
- 1 specimen, No. 2780 B. O. C. Station 27, March 18, 1927. 24° 45' N. 76° 21' W. 8000 feet wire.
- 5 specimens, No. 2899 B. O. C. Station 31, March 21, 1927. 24° 29' N. 75° 53' W. 7000 feet wire.
- 11 specimens, No. 2791 B. O. C. Station 33, March 22, 1927. 24° 11' N. 75° 37' W. 8000 feet wire.
- 4 specimens, No. 2778 B. O. C. Station 35, March 23, 1927. 24° 11' N. 75° 35' W. 7500 feet wire.
- 6 specimens, No. 2783 B. O. C. Station 39, March 29, 1927. 22° 42' 33'' N. 74° 23' W. 8000 feet wire.
- 3 specimens, No. 2787 B. O. C. Station 41, March 30, 1927. 22° 31' N. 74° 26' W. 10,000 feet wire.
- 2 specimens, No. 2790 B. O. C. Station 46, April 4, 1927. 21° 46' N. 72° 50' W. 10,000 feet wire.
- 2 specimens, No. 2788 B. O. C. Station 48, April 6, 1927. 21° 44' N. 72° 43' W. 7000 feet wire.
- 1 specimen, No. 2781 B. O. C. Station 52, April 11, 1927. 21° 30' N. 71° 11' W. 8000 feet wire.
- 3 specimens, No. 2782 B. O. C. Station 56, April 13, 1927. 21° 20' N. 71° 13' W. 6500 feet wire.
- 1 specimen, No. 2776 B. O. C. Station 58, April 20, 1927. 32° 24' N. 64° 29' W. 5000 feet wire.

5 specimens, No. 2786 B. O. C. Station 58, April 20, 1927. $32^{\circ} 24' N.$ $64^{\circ} 29' W.$ 10,000 feet wire.

4 specimens, No. 2784 B. O. C. Station 59, April 21, 1927. $32^{\circ} 19' 18'' N.$ $64^{\circ} 32' 30'' W.$ 8000 feet wire.

Family **STOMIATIDAE**

Genus **Stomias** Cuvier

Stomias valdiviae Brauer

1 specimen, No. 2668 B. O. C. Station 18, March 10, 1927. $23^{\circ} 42' N.$ $76^{\circ} 43' W.$ 7000 feet wire.

Length without caudal fin 155 mm. Proportions in per cent of the length without caudal fin: Depth 8.5. Head 10.3. Eye 2.0. Snout to V 75. Vent to base of caudal fin 15.2.

D 18. A 24.

Photophores in the ventral series: Isthmus to P 11. P-V 44. V-A 6. A-C 17.

For other records of individual counts and measurements, in addition to those in Brauer's original description, see Ege 1918, p. 23.

Family **CHAULIODONTIDAE**

Genus **Chauliodus** Bloch and Schneider

Chauliodus sloanei Schneider

5 specimens, No. 2918 B. O. C. Station 5, February 26, 1927. $25^{\circ} 56' N.$ $77^{\circ} 37' W.$ 5000 feet wire.

2 specimens, No. 2915 B. O. C. Station 7, February 28, 1927. $24^{\circ} 00' N.$ $77^{\circ} 17' W.$ 6000 feet wire.

2 specimens, No. 2916 B. O. C. Station 9, March 1, 1927. $23^{\circ} 55' N.$ $77^{\circ} 09' W.$ 4000-7000 feet wire.

1 specimen, No. 2919 B. O. C. Station 11, March 2, 1927. $23^{\circ} 58' N.$ $77^{\circ} 26' W.$ 7000 feet wire.

3 specimens, No. 2927 B. O. C. Station 14, March 8, 1927. $24^{\circ} 35' N.$ $77^{\circ} 36' 20'' W.$ 8400 feet wire.

1 specimen, No. 2920 B. O. C. Station 18, March 10, 1927. $23^{\circ} 42' N.$ $76^{\circ} 43' W.$ 7000 feet wire.

5 specimens, No. 2922 B. O. C. Station 22, March 12, 1927. $23^{\circ} 37' N.$ $77^{\circ} 15' W.$ 7000 feet wire.

1 specimen, No. 2917 B. O. C. Station 23, March 14, 1927. $24^{\circ} 29' N.$ $77^{\circ} 29' W.$ 8000 feet wire.

1 specimen, No. 2921 B. O. C. Station 27, March 18, 1927. $24^{\circ} 45' N.$ $76^{\circ} 21' W.$ 8000 feet wire.

- 1 specimen, No. 2926 B. O. C. Station 31, March 21, 1927. 24° 29' N. 75° 53' W. 7000 feet wire.
- 1 specimen, No. 2925 B. O. C. Station 33, March 22, 1927. 24° 11' N. 75° 37' W. 8000 feet wire.
- 1 specimen, No. 2924 B. O. C. Station 43, March 31, 1927. 22° 12' 15" N. 74° 19' W. 4000 feet wire.
- 1 specimen, No. 2914 B. O. C. Station 56, April 13, 1927. 21° 20' N. 71° 13' W. 6500 feet wire.
- 3 specimens, No. 2923 B. O. C. Station 58, April 20, 1927. 32° 24' N. 64° 29' W. 5000 feet wire.

Chauliodus danae Regan and Trewavas

- 1 specimen, No. 2935 B. O. C. Station 7, February 28, 1927. 24° 00' N. 77° 17' W. 6000 feet wire.
- 1 specimen, No. 2933 B. O. C. Station 9, March 1, 1927. 23° 55' N. 77° 09' W. 4000-7000 feet wire.
- 2 specimens, No. 2941 B. O. C. Station 11, March 2, 1927. 23° 58' N. 77° 26' W. 7000 feet wire.
- 1 specimen, No. 2931 B. O. C. Station 23, March 14, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.
- 5 specimens, No. 2938 B. O. C. Station 25, March 17, 1927. 24° 51' N. 76° 37' W. 8000 feet wire.
- 1 specimen, No. 2932 B. O. C. Station 27, March 18, 1927. 24° 45' N. 76° 21' W. 8000 feet wire.
- 2 specimens, No. 2934 B. O. C. Station 31, March 21, 1927. 24° 29' N. 75° 53' W. 7000 feet wire.
- 1 specimen, No. 2930 B. O. C. Station 35, March 23, 1927. 24° 11' N. 75° 35' W. 7000 feet wire.
- 2 specimens, No. 2936 B. O. C. Station 41, March 30, 1927. 22° 31' N. 74° 26' W. 10,000 feet wire.
- 4 specimens, No. 2940 B. O. C. Station 52, April 11, 1927. 21° 30' N. 71° 11' W. 8000 feet wire.
- 1 specimen, No. 2937 B. O. C. Station 54, April 12, 1927. 21° 16' N. 71° 18' W. 900-945 fathoms.
- 3 specimens, No. 2929 B. O. C. Station 56, April 13, 1927. 21° 20' N. 71° 13' W. 6500 feet wire.
- 6 specimens, No. 2928 B. O. C. Station 58, April 20, 1927. 32° 24' N. 64° 29' W. 5000 feet wire.
- 6 specimens, No. 2939 B. O. C. Station 59, April 21, 1927. 32° 19' N. 64° 33' W. 8000 feet wire.

Order **LYOMERI****Eurypharynx pelecánoides** Baillant 1882

- 4 specimens, No. 2903 and 2907 B. O. C. Station 11, March 2, 1927. 23° 27' 25" N. 77° 26' 25" W. 7000 feet wire.
- 1 specimen, No. 2904 B. O. C. Station 16, March 9, 1927. 23° 49' 15" N. 76° 58' 30" W. 7000 feet wire.
- 1 specimen, No. 2909 B. O. C. Station 23, March 14, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.
- 2 specimens, No. 2905 B. O. C. Station 39, March 29, 1927. 22° 42' 33" N. 74° 23' W. 8000 feet wire.
- 1 specimen, No. 2952 B. O. C. Station 46, April 4, 1927. 21° 46' 12" N. 72° 49' 30" W. 10,000 feet wire.
- 1 specimen, No. 2908 B. O. C. Station 48, April 6, 1927. 21° 44' N. 72° 43' 25" W. 7000 feet wire.
- 1 specimen, No. 2906 B. O. C. Station 59, April 21, 1927. 32° 19' N. 64° 32' W. 8000 feet wire.

Accepting the synonymization of the genera *Eurypharynx*, *Gastrostomus* and *Macropharynx*, and of all species described previous to 1914, as proposed by Zugmayer and further elaborated by Roule (see Roule 1919, pp. 93-94), the author feels strongly inclined to doubt that *E. richardi* Roule should be kept exempt from the fate of the other nominal forms. As regards the number of pectoral rays this seems very difficult to ascertain without a complete dissection and removal of the fin, chiefly for the reason that the two halves of several of the rays appear to be normally completely separated from each other and are very frequently (always?) so arranged in the fin membranes that they do not cover each other, but diverge slightly thus making it appear to an external inspection as if they were two independent rays. In the specimens examined by the writer the actual number of rays, counted at their bases, fluctuates from 8 to 12, 9 and 10 being most common, while the distal counts on undissected fins would often give figures which were higher by 2-4 on account of the impossibility of distinguishing accurately between separate halves of the same ray and truly distinct separate fin rays. With these conditions making it difficult to trust to the pectoral fin counts, there seems to be little other reason for maintaining *E. richardi* as separate from *E. pelecánoides*.

Order **HETEROMI**Family **HALOSAURIDAE****Aldrovandia** sp.

- 1 specimen, No. 3731 B. O. C. Station 54, April 12, 1927. 21° 16' N. 71° 18' W. 7500 feet wire.
- 3 specimens, No. 3732 B. O. C. Station 54. April 12, 1927. 21° 16' N. 71° 18' W. 7500 feet wire.

The specimens above listed may represent a new species or may possibly belong to *A. rostrata* (Günther), but lacking material for comparison definite identification cannot be made. The specimens agree with Günther's figures and description of *A. rostrata* with regard to the relative positions of dorsal and ventral fins and in general appearance, but has a somewhat shorter snout on which point they agree with *A. affinis* Günther. All the lateral line scales are lost.

Order **ANACANTHINI**

Family **GADIDAE**

Melanonus unipennis Beebe 1932

Melanonus unipennis Beebe 1932, p. 74.

10 specimens, No. 2862 B. O. C. Station 58, 20/4, 1927. 32° 24' 15" N. 64° 29' W. 10,000 feet wire.

8 specimens, No. 2863, B. O. C. Station 59, 21/4, 1927. 32° 19' 18" N. 64° 32' 30" W. 8000 feet wire.

Although it might at first thought seem unreasonable to refer a species with confluent first and second dorsals to a genus in which these fins are otherwise only known to be entirely separate, the author is nevertheless entirely in agreement with the classification proposed by Dr. Beebe, the presence or absence of fin membrane between the elevated anterior group of dorsal rays and the rest of the dorsal fin apparently being of only slight significance in species of this particular type. Attention might be called to the fact that the anterior dorsal rays are free from the fin membrane by $\frac{1}{3}$ to $\frac{1}{2}$ of their length, the membrane being particularly low at the transition from the anterior rays to the rest of the fin (around the 7th to 8th ray), although its height is nowhere less than around $\frac{1}{2}$ of the length of the rays it contains, and it is not completely interrupted at any point. There is no suggestion of an unequal spacing of the dorsal fin rays as indicated in Norman's figure of *M. zugmayeri* (Norman 1930, fig. 35, p. 341). The remaining dorsal rays and the rays of first anal fin also have their tips free from the membrane.

? **Laemonema melanurum** Goode and Bean 1895

1 specimen, No. 2913 B. O. C. Station 58, 20/4, 1927. 32° 24' 15" N. 64° 29' W. 10,000 feet wire.

The above recorded young specimen, 73 mm. long, differs from young specimens of *L. barbatula* Goode and Bean, seen by the author, in its higher scale count (about 155-160 scales in lateral line) and has therefore been tentatively referred to *L. melanurum*, although it is difficult to draw any definite conclusions as to identity from a comparison between the description of the 330 mm. long type of *L. melanurum* and a specimen as small as the one here reported upon.

Bregmaceros atlanticus Goode and Bean

- 2 specimens, No. 3725. Station 18, March 10, 1927. 23° 42' N. 76° 43' W. 7000 feet wire.
6 specimens, No. 2692 B. O. C. Station 23, March 14, 1927. 24° 29' N. 77° 29' W. 8000 feet wire.
1 specimen, No. 32726. Station 56, April 13, 1927. 21° 21' N. 71° 13' W. 6500 feet wire.

ADDENDA AND CORRIGENDA

TO PRECEEDING REPORTS ON THE FISHES OF THE
THIRD OCEANOGRAPHIC EXPEDITION OF THE "PAWNEE"

Omosudis lowei Günther

- 1 specimen, No. 2953 B. O. C. Station 27, March 17, 1927. N. 24° 45'. W. 76° 21', 8000 feet wire.
1 specimen, No. 2954 B. O. C. Station 48, April 6, 1927. N. 21° 44'. W. 72° 43'. 7000 feet wire.

For a description and discussion of anatomy and classification see Parr (1928, p. 172; 1929, p. 35).

MYCTOPHINAE

For further revisions of this group (genera *Myctophum*, *Lampanyctus*, *Diaphus* and *Lampadena*) see particularly Taning (1932), Parr (1929, 1931a, 1934a).

Neoscopeus macrolepidotus? Johnson

- 1 specimen, No. 3728 B. O. C. Station 52, April 4, 1927. 21° 30' N. 71° 11' W. 8000 feet wire out.

A small specimen of *Neoscopeus* only about 30 mm. long without caudal fin, apparently belonging to *N. macrolepidotus*.

Genus Kali Lloyd 1909

Kali Lloyd 1909, p. 154.

Dolichodon Parr 1931a, p. 45.

Hemicyclodon Parr 1931b, p. 162, 1933, pl. 35.

For some reason or other, several of the contributions made by Lloyd in his 1909 report seem to have escaped the attention of subsequent investigators. Thus the genus *Platytröctegen* Lloyd is not mentioned in the keys to the family Alepocephalidae (see page 7) subsequently published by Norman (1930) and by Beebe (1933); nor is the genus *Kali* Lloyd referred to in Norman's revision of the Chiasmodontidae (Norman 1929) which formed the basis for the introduction by the present writer of the generic designation *Dolichodon* subsequently

changed to *Hemicyclodon* due to preoccupation of the former name. From the description given by Lloyd there can be no doubt that *Hemicyclodon* Parr is merely a synonym for *Kali* Lloyd.

Kali indica Lloyd is distinguished from the other species listed in the previously published key to the genus (Parr 1933, p. 35) by having even larger eyes (5 in head) than *K. macrodon* (Norman) but a lower fin-count (22) in the second dorsal.

***Lophogobius glaucofraenum* (Gill)**

Lophogobius pallidus Parr 1930b, p. 112, fig. 33.

After previously accepting *L. pallidus* Parr as a separate species, Beebe and Tee-Van (1933, p. 153) synonymize this form with *L. glaucofraenum* (Gill) and this interpretation is also now accepted by the present writer.

***Callionymus bermudarum* Barbour**

Callionymus dubiosus Parr 1930b, p. 130, fig. 36.

Upon reëxamination of the type of *C. bermudarum* Barbour, Beebe and Tee-Van (1933, p. 155) discovered the presence of 5, possibly 6, dorsal spines instead of only 3 as originally reported, thus proving the identity between this species and *C. dubiosus* Parr in which they also observed a fifth rudimentary spine.

Genus *Xenoceratias* Regan and Trewavas 1932

Regan and Trewavas (1932, pp. 54-57) refer the following three species previously described by Parr (1927 and 1930a) to their new genus *Xenoceratias*.

***Xenoceratias acanthirostris* (Parr)**

Rhynchoceratias acanthirostris Parr, 1927, p. 31, fig. 11.

***Xenoceratias longipinnis* (Parr)**

Rhynchoceratias longipinnis Parr, 1930a, p. 7, figs. 2-5.

Type specimen N. 2592 of the Bingham Oceanographic Collection (stained with alizerin and cleared in glycerin) not recorded in first account of the Cera-tioidea of the third oceanographic expedition of the "Pawnee". For specific diagnosis see Parr. 1930, p. 7.

***Xenoceratias latirhinus* (Parr)**

Rhynchoceratias latirhinus Parr, 1927, p. 31, fig. 12.

***Chaenophryne quadrifilis* Parr**

Chaenophryne longiceps var. *quadrifilis* Parr, 1927, p. 22, fig. 8A.

Chaenophryne quadrifilis Regan and Trewavas, 1932, p. 87, fig. 136.

Variety first described by Parr (1927), elevated to specific rank by Regan and Trewavas (1932) with specimen No. 2910 (Ex. 2007) of the Bingham Oceanographic Collection herewith designated as the type. The minute anterior prominence on the bulb of the illicium is double.

***Linophryne arborifera eupogon* Regan and Trewavas**

L. eupogon Regan and Trewavas 1932, p. 110.

L. arborifera Parr 1927, p. 10, fig. 3.

L. arborifera eupogon Parr 1934b, p. 46, fig. 14.

This form was designated by Regan and Trewavas (1932) as a separate species, on the basis of the figure and description of specimen No. 2029 (TYPE) of the Bingham Oceanographic Collection given by Parr (1927). The original specimen has subsequently been redescribed and illustrated (barbel only) in greater detail by Parr (1934) as a subspecies, only, and the reasons for this interpretation of its taxonomic rank are given in a discussion of the classification of the entire genus *Linophryne* in the same paper (Parr, 1934, p. 41).

SUMMARY

Family Alepocephalidae

- (1) A tentative revised synopsis of the genera is given on pp. 2-8.
- (2) Four new genera are introduced, two on the basis of previous descriptions, two from new material (see list of new genera and species).
- (3) It is pointed out that *Normannia* n. gen. does probably not pertain to the Alepocephalidae, p. 9.
- (4) Reasons are given for synonymizing *Xenodermichthys socialis* with *X. copei*, p. 20.
- (5) *Bathytroctes drakei* is referred to the genus *Bajacalifornia*.
- (6) The genera *Asquamiceps* (p. 10), *Conocard* (p. 10), *Whitleydea* (p. 12), *Talismania* (p. 21), and *Bajacalifornia* (p. 24) are subject of special comment.
- (7) It is suggested that *Bathytroctes rostratus* Günther may have been currently misidentified with *Searsia koefoedi* n. sp., p. 12.

Family Opisthoproctidae

- (1) THE POSSIBLE RELATIONSHIP BETWEEN A PROBABLE PERMANENT SHORTAGE OF VITAMIN D IN THE APHOTIC DEPTHS AND THE TERATOLOGIC LOOKING LACK OF OSSIFICATION IN THIS AND OTHER GROUPS OF DEEP-SEA FISHES IS POINTED OUT, p. 27.
- (2) THE DECREASING ENERGY INEFFICIENCY OF THE SWIMBLADDER FUNCTION WITH INCREASING DEPTH AND HYDROSTATIC PRESSURE IS DISCUSSED AND THE LIKELIHOOD OF SWIMBLADDERS NOT BEING FUNCTIONAL EVEN WHEN ANATOMICALLY PRESENT IN GREAT DEPTHS IS MENTIONED, p. 32.

- (3) Supplementary notes and illustrations of the osteology of *Opisthoproctus* are given on pp. 27-31.

Family **Dolichopterygidae**

- (1) A discussion of the species of *Dolichopteryx* with a revised key to the genus is given on pp. 33-37.
 (2) One new species is described.

Family **Gonostomatidae**

- (1) Illustrations are given of the variability of photophore arrangements in *Gonostoma bathyphilum*, fig. 17, p. 42.

Family **Sternoptychidae**

- (1) The classification of the species of *Argyropelecus* is discussed, with a key to the genus and illustration of 6 species, pp. 46-53.
 (2) A new species of *Argyropelecus* is described.
 (3) A key to the genus *Polyipnus* is given, with a new illustration of *P. laternatus*, p. 54.

A COMPLETE GENUS AND SPECIES INDEX TO THE FISHES REPORTED FROM THE THIRD OCEANOGRAPHIC EXPEDITION OF THE "PAWNEE" IS GIVEN ON PP. 69-79.

New Genera and Species Described in this Report

NEW GENERA

<i>Normania</i> (genotype <i>Alepocephalus andersoni</i> Fowler)	p. 9
<i>Holtbyrnia</i> (genotype <i>Bathytroctes innesi</i> Fowler)	p. 6
<i>Searsia</i> (genotype <i>S. koefoedi</i> n. sp.)	p. 12
<i>Binghamia</i> (genotype <i>B. microphos</i> n. sp.)	p. 22

NEW SPECIES

<i>Searsia koefoedi</i> . <i>S. polycoeca</i>
<i>Binghamia microphos</i>
<i>Dolichopteryx brachyrhynchus</i>
<i>Argyropelecus micracanthus</i>

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INDEX TO GENERA, SPECIES AND SYSTEMATIC GROUPS

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FISHES OF THE THIRD OCEANOGRAPHIC EXPEDITION OF THE "PAWNEE"

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A PRACTICAL REVISION OF THE WESTERN ATLANTIC SPECIES OF THE GENUS CITHAR- ICHTHYS (INCLUDING ETROPUS).¹

With Observations on the Pacific CITHARICHTHYS CROSSOTUS and
C. SPILOPTERUS.

BY ALBERT EIDE PARR

Curator of the Bingham Oceanographic Collection.

INTRODUCTION

In the course of the coöperative Fisheries and Marine Biological Survey of the Delaware Bay region, carried on jointly by the United States Bureau of Fisheries and the Bingham Oceanographic Foundation under the direction of the writer, an uncertainty soon developed as to the proper taxonomic designation for a species of the *Etropus-Citharichthys* group of flat-fishes, which was found to occur quite abundantly within the area investigated. Further study of this problem has gradually led to a revision of all of the various species from the Atlantic coast of North and Middle America previously referred to the two above mentioned genera, which are herewith, at least provisionally, combined into one, for reasons below made out.

In addition to the material from the Delaware Bay region the writer has also had opportunity to study other collections made by the United States Bureau of Fisheries, as well as the types and other samples deposited in the United States National Museum and the Museum of Comparative Zoölogy of Harvard University. Special thanks are due Mr. William C. Schroeder for his generous permission to make use of his notes on several of the species to be dealt with on the following pages.

Arising out of the difficulties met with in the identification of the Delaware Bay material, the following revision is solely intended to present the reader with a practical means for the classification of the species occurring in western Atlantic waters; with no pretensions at solving the complicated problem of their probable natural relation-

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ship, although some observations bearing upon this point will be made in the general discussion of their classification. This problem, however, is one which would require a world-wide revision not only of the group here considered, but also of a number of other related genera; a task for which the author unfortunately has neither the time nor the material available. For similar reasons no attempt has been made at rendering a full list of references for each species, while the synonymies, on the other hand, are believed to be complete and all species are redescribed from actual study of the types and other specimens.

CLASSIFICATION

The various species to be dealt with on the following pages will, as already above mentioned, generally be found to be referred to two separate genera, *Citharichthys* and *Etropus*, the latter differing from the former "only in the very small size of the mouth and in the correspondingly weak dentition."¹ The vagueness of the distinction is already obvious from this definition, and the author's own observations have shown the impracticability of basing a generic subdivision upon this feature alone, although the actual arrangement of the species proposed by Jordan and Evermann (*rimosus*, *crossotus* and *microstomus* in the genus *Etropus*, the rest of the species in the genus *Citharichthys*) may perhaps to some extent express the natural relationship of the three forms thus included in the genus *Etropus*, while leaving the genus *Citharichthys* as a very heterogeneous group, if judged by systematic standards of a similar exactitude to that which prompted the segregation of the genus *Etropus*. The actual impracticability of the subdivision may, however, be seen from the following considerations.

If the length of the maxillary (expressed in per cent of the total length without caudal fin) be taken as an expression of the size of the mouth the species would arrange themselves as follows:

1. *rimosus* (maxillary length 5.9–6.3 per cent); 2. *microstomus* (max. 5.7–6.8); 3. *crossotus* (4.8–8); 4. *arctifrons* (7–7.5); 5. *macrops*, *spilopterus*, *uhleri* and *arenaceus* (9.5–12); 6. *unicornis* and *dinoceros* (11.5–13).

The difficulty in point of this feature is particularly due to the proportions of No. 4, *arctifrons*, which has not heretofore been included

¹ Jordan and Evermann; Fishes of North and Middle America, p. 2687.

in the *Etropus* group (Nos. 1-3); and which apparently has no closer relationship to the latter forms, in spite of its relatively short maxillary. If descriptive terms be used it might be said that *arctifrons* is nevertheless fairly easily distinguishable from *crossotus* by the relatively greater extent to which its maxillary reaches beyond the ventral margin of the left orbit (apart from other specific characters by which these two forms are easily differentiable); but it is obviously impracticable to utilize a feature of this vaguely defined nature as the basis for any subdivisions of generic rank. If the species here considered are further arranged in a comparative tabulation in which their natural grouping in point of the relative development of each of the various characters, mentioned at the head of each column, is indicated by group symbols in Roman figures (as in the accompanying table)

COMPARATIVE TABULATION OF THE WESTERN ATLANTIC SPECIES OF THE GENUS
Citharichthys, sensu lato.

Species	Length of maxil- lary	Relative reach of maxil- lary ¹	Squama- tion of snout	Sec- ondary squama- tion	Gill- rakers	Size of eyes	Number of scales
<i>rimosus</i>	I	I	I	I	I	II	I
<i>microstomus</i>	II	III	II	II	I	II	I
<i>crossotus</i>	III	II	III	III	III	II	I
<i>arctifrons</i>	IV	IV	II	III	II	II	I
<i>spilopterus</i>	V	V	III	III	IV	I	II
<i>uhleri</i>	V	VI	III	III?	V	I	II
<i>arenaceus</i>	V	VI	III	II/III ⁴	V	I	II
<i>macrops</i>	V	VI	II/III ²	III?	V	III	I
<i>unicornis</i>	VI	VI	II-III ²	III?	V	IV	I
<i>dinoceros</i>	VI	VI	?	III?	III	IV	II

¹ In relation to the orbits.

³ Secondary sexual difference.

² Intermediate.

⁴ Present or absent.

the impossibility of making any simple dichotomous subdivisions among these forms will soon become apparent. It will be seen from this table that the sequence into which the species naturally arrange themselves according to the length of the maxillary is not the order in which they would have to be listed according to any other feature, except possibly in regard to the squamation on the snout, concerning which, however, absolutely reliable information is lacking for almost half of the species due to poor preservation of the skin on these parts.

With these remarks the author does not intend to say that a further

subdivision would not be desirable for obtaining a more natural classification of the species concerned; but merely that this purpose has not been accomplished by the distinction currently made between the two genera *Etropus* and *Citharichthys*, and should not be attempted without an extensive anatomical and descriptive revision not only of the species directly involved, but also of all related groups of flat-fishes. As it seems to the writer, we have two apparently fairly natural groups among the ten species dealt with on the following pages; the first comprising the species *rimosus*, *microstomus*, and *crossotus*; the second, *spilopterus*, *uhleri*, *arenaceus*, and (perhaps?) *macrostomus*. Still there would seem to be a sufficient amount of approximation between these two groups to make them appear to be perhaps *more closely related to each other than to any of the three remaining species, arctifrons, unicornis and dinoceros*; each of which apparently occupies a fairly isolated position.

BODY PROPORTIONS AND GROWTH

A considerable number of measurements of the relative width of the body at different total lengths have given quite interesting results with regard to specific differences of an ontogenetic nature. While a distinct increase in the relative width of the body, even long after the specimens have in all other respects attained the features of the fully developed adult, is characteristic of a number of the species, it appears that the relative magnitude of these late ontogenetic changes is entirely independent upon the proportions finally attained by the fully grown fish. It would be natural to assume that a form specifically characterized by a very wide body would show a more protracted development of this body-width than would a species of more slender proportions. This, however, is not the case, as will appear from the accompanying diagram, which shows almost no indications at all of any changes in the proportions of the widest of the three species compared (*crossotus*), while the comparatively very slender *arctifrons*, and the intermediate *microstomus* both show a very marked increase in width over the same range of total lengths. A similarly constant width of the body as in *C. crossotus* is also observed in *C. spilopterus* (p. 21 fig. 9) and *C. unicornis* (p. 19 fig. 8). For this reason it is highly desirable that the normal curves for these changes in the proportions, or the lack of such changes, should be established as adequately as

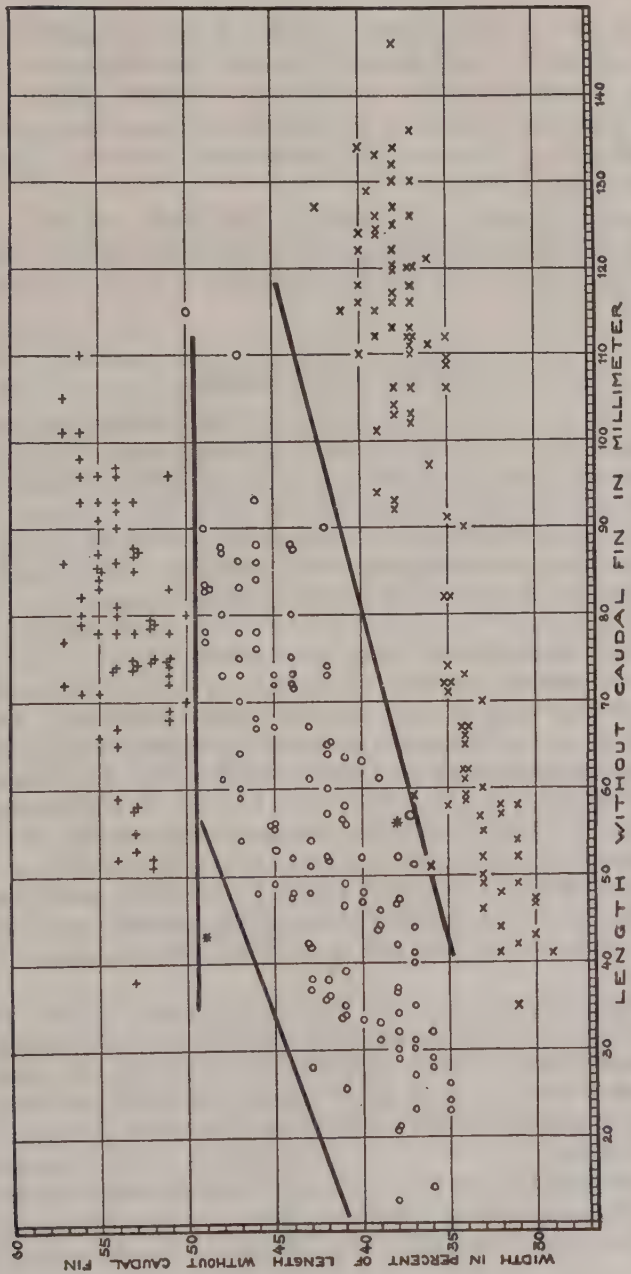


Figure 1. Correlation between relative width of body and absolute length without caudal fin in *Citharichthys crosseolus atlanticus* (+), *C. microstomus* (circles), and *C. artifrons* (X). Approximate boundaries between the three forms are indicated by straight solid lines. Upper asterisk represents a *C. microstomus* of deviating width, lower asterisk a similarly deviating *C. artifrons*.

possible for each individual species, and it seems quite probable that these growth-curves might prove of considerable value as an aid to taxonomy; especially when comparisons between geographically separate but descriptively very similar forms are made, as in the case of the Pacific and Atlantic populations of *C. crossotus*, *sensu lato*, discussed on pages 15-17.

The gradual decrease in the relative size of the eyes of *C. microstomus*, and the increase in interorbital width in the male *C. unicornis* have been worked out and presented graphically on pages 12 and 19, respectively.

KEY TO THE SPECIES

- I. Scales large and body relatively narrow so that there are only about 8-9 scales between lateral line and dorsal fin and 8-10 between lateral line and anal. About 40 scales in lateral line. Width always less than 45, usually not over 40, per cent of length without caudal fin. Mouth moderate, maxillary about 7-7.5 per cent of length without caudal. Only about 6-7 gillrakers in the lower portion of the first arch. Left pectoral small. Eyes moderate. Snout in adults with a blunt osseous prominence. (Comp. II-V below).
 1. *C. arctifrons* (p. 8).
- II. Scales small, about 48 in the lateral line, 14 between lateral line and dorsal fin, and 16 between lateral line and anal. Only about 8 gillrakers in the lower portion of the first arch. Eyes very large. Mouth large, maxillary about 13 per cent of length without caudal. Left pectoral fin greatly produced, about two-fifths of the length without caudal. D. about 91. A about 73. (Comp. I-V).
 2. *C. dinoceros* (p. 8).
- III. Scales moderate, 38-46 in the lateral line and always more than 10 between lateral line and dorsal fin and more than 11 between lateral line and anal. Gillrakers only 5-9 in lower part of first arch. Mouth small, maxillary only about 5(4.8) to 8 per cent of the length without caudal fin. Left pectoral short, not over one-fourth of the length without caudal. (Comp. I-V).
 - A. Entire snout covered with a dense squamation of very coarsely ctenoid and thickened scales. Secondary squamation strongly developed, with numerous small scales covering almost the entire free surface of each primary scale. Mouth very small, head thick, and interorbital space high. Only about 5 gillrakers in lower part of first arch.
 3. *C. rimosus* (p. 9).
 - B. Snout with thin, finely ctenoid scales in front of the orbits, but only partly covered farther forward. Secondary squamation moderate, never covering more than the anterior half of the free portion of each

primary scale in the form of relatively few (2-7, usually about 5) smaller scales. Usually only 5 gillrakers in lower part of first arch (very rarely 6 or 7). Only about 11-13 scales between lateral line and dorsal fin. Body narrower than in specimens of the following species of comparable size. 4. *C. microstomus* (p. 11).

- C. No scales anterior to the interorbital space. No secondary squamation. About 14-17 scales between lateral line and dorsal fin. 6-9 gillrakers in lower part of first arch, usually 7-8. Width of body about equal to 50 per cent of the length without caudal fin, or more.

5. *C. crossotus atlanticus* (pp. 13 and 16).

- IV. Scales moderate or small, about 12 or more between lateral line and dorsal fin. Gillrakers relatively numerous, about 10 to 14 in lower part of first arch. Mouth moderate or large, maxillary about 9.5-13 per cent of length without caudal. (Comp. I-IV).

- A. Eyes very large, 8.8-10 per cent of length without caudal. Scales moderate, about 40 in the lateral line, about 12 between lateral line and dorsal fin and the same number between lateral line and anal. Head large, 28-29 per cent of length without caudal, maxillary 11.5-13 per cent. Males with cephalic spines and greatly expanded interorbital space. Small deep water form. 6. *C. unicornis* (p. 17).

- B. Eyes fairly large, 7-8 per cent of length without caudal. Scales moderate, about 40-41 in lateral line, about 15 between lateral line and dorsal fin and about 16 between lateral line and anal. Head moderate in adults, larger in young (?), 23-27 per cent of length without caudal, maxillary 10-12 per cent. 7. *C. macrops* (p. 20).

- C. Eyes small, less than 6 per cent of length without caudal. Scales small, about 46-53 in the lateral line, about 15-18 between lateral line and dorsal fin and about 16-21 between lateral line and anal. Maxillary 9.5-12 per cent of length without caudal.

1. D. 79-82. A. 59-60. About 46-49 scales in lateral line.

Snout equal to eyes, or about 4.3-5.5 per cent of length without caudal. Width of body about 41-51 per cent.

8. *C. spilopterus* (p. 21).

2. D. 68-75. A. 48-54. About 50-52 scales in lateral line. Snout (5-6 per cent of length without caudal) longer than eyes, which are only 4-4.5 per cent. Width of body usually more than 50 per cent of length without caudal. 9. *C. arenaceus* (p. 22).

3. D. about 68. A. about 52. About 53 scales in the lateral line. Snout about equal to eyes or about 5 per cent of length without caudal. 10. *C. uhleri* (p. 23).

Citharichthys artifrons Goode

Citharichthys artifrons Goode, Proc. U. S. National Mus. Vol. III, 1880, p. 341, 472.

GENERAL DESCRIPTION: Mouth moderate, maxillary extending well beyond a parallel with the axis of the body drawn through the ventral margin of the left eye. Length of maxillary about 7-7.5 per cent of total length without caudal fin. Eyes large, about 5-7.5 per cent, head about 21-27 per cent of the same length, the relative values of both of these measurements showing a distinct decrease with growth. Head very flat with depressed orbits. Snout with a blunt osseous protuberance extending straight forward in a continuation of the body axis, usually reaching well beyond the upper lip in the adults, less developed in the younger specimens. A band of minutely ctenoid scales present on the snout in front of the right orbit and a less developed row along the left. About 6-7 rows of scales between left orbit and preopercular margin. Gillrakers short and thick, only 6-7 in the lower half and about 5 in the upper half of the first arch. Although a slender species, with the width of the body never attaining to a value as high as 45 per cent, and only rarely exceeding 40 per cent, of the length without caudal fin, it nevertheless shows a very distinct increase in width with growth, as already shown in the diagram on page 5, from which the usual proportions at the various stages can be seen. Scales large and extremely deciduous, particularly on the left side, where only very rarely any but those of the lateral line are preserved. The scale pockets are very distinct, however, and can easily be counted. About 40 in the lateral line, but only 7-9 between lateral line and dorsal fin, and 8-10 between lateral line and anal fin. Scales mostly cycloid, occasionally microscopically ctenoid.

D. 78-83. A. 61-67. Pectorals small, length of right pectoral only about 9-10 per cent of total length without caudal fin, left pectoral about 14-15 per cent.

DISCUSSION: This species appears to be quite abundant on the continental shelf between Cape Cod and Cape Hatteras in depths from about 40 to about 200 fathoms, but no extensive information in regard to its total range of distribution is available at the present time.

Reaches a length of about 150 mm. without caudal fin.

Citharichthys dinoceros Goode and Bean

Citharichthys dinoceros Goode and Bean, Bull. Mus. Comp. Zool. Vol. 12, No. 5, p. 157. 1886.

GENERAL DESCRIPTION: Mouth very large. Maxillary equal to about 13 per cent of the length without caudal fin and extending much (by one-third of its length) beyond a parallel with the axis of the body drawn through the ventral margin of the left orbit, even reaching to the transverse level of the centre of the left eye. Eyes very large, about 8.7 per cent of the length without caudal.

Snout shorter, about 6.5 per cent of the same measurement. The snout is characterized by a small, but very strong, forwardly directed spine situated directly in front of the middle of the right orbit at a short distance from its anterior margin. A blunt, spinelike, transverse projection is also found near the end of the snout at the edge of the upper labial fold. Some scales may have been found immediately in front of the mesial half of the anterior margin of the right orbit, but the snout otherwise appears to have been entirely naked in the type. Head very flat, its length about 29 per cent of the total length without caudal fin. Interorbital space very narrow, with a sharp, but only very slightly elevated ridge. About 7-9 rows of scales between the left orbit and the free preopercular margin. 3 small gillrakers in the upper part and 8-9 fairly long and slender ones in the lower part of the first arch. Left preopercular with a blunt, spinelike projection at its ventral end. Body comparatively slender, its width only about 44 per cent of the length without caudal fin. Left pectoral fin greatly produced so as to equal fully two-fifths (41 per cent) of the length without caudal fin, while the right pectoral fin is normal and only equals about 13 per cent of the same measurement.

Scales of moderate size, finely ctenoid, about 48 in the lateral line and about 14 between lateral line and dorsal fin and 16 between lateral line and anal. The scale pockets show no indications of any secondary squamation having been present.

D. 91. A. 73.

DISTRIBUTION: A deep water form known only from a few specimens from West Indian waters taken in 300 to 1,000 fathoms depth.

***Citharichthys rimosus* GOODE and BEAN**

Eltopus rimosus Goode and Bean, Proc. U. S. Nat. Mus., Vol. VIII, 1885, p. 593.

GENERAL DESCRIPTION OF SPECIMENS OF 85-100 MM. LENGTH WITHOUT CAUDAL FIN: Mouth very small, maxillary only just reaching to a parallel with the axis of the body drawn through the ventral margin of the left orbit. Length of maxillary only equalling 6 per cent of the total length without caudal fin. Eyes about 6.5-7 per cent of the same measurement. Length of head 23-24 per cent. Interorbital region strongly elevated, and very rough from a dense squamation of small, coarsely ctenoid scales with their free portion characteristically thickened and modified (see figure 2). Similar scales also cover the entire snout to the upper margin of the maxillary groove. A small patch of scales is also found on the dorsal surface of each eye-ball itself. About 8 rows of scales between the left orbit and the preopercular margin. Primary scales on head and body very finely ctenoid, quite distinctly so on the blind side but often hardly recognizably on the left, where the spines may be reduced to a badly differentiated, quite microscopic roughness in the outline of the scale.

Each primary scale is completely covered by a great number of secondary (or accessory) scales forming an intricate and highly variable pattern (see figure 3) in which several orders even of the secondary scales can be recognized,

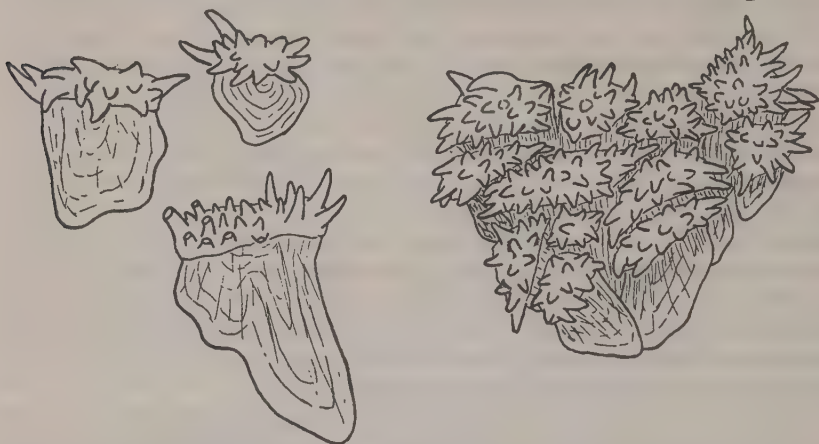


Figure 2. Scales from the snout of *Citharichthys rimosus*. Separate scales at left, a small group in natural arrangement at right. The lower scale at left shows the abrasion of the spines in exposed positions.



Figure 3. Primary and secondary squamation of *Citharichthys rimosus*. Sample taken from the blind side of the fish.

relatively larger ones being again covered by others of yet smaller size. This arrangement lends to the species the "frosted" appearance for which it has been given its name. About 40-41 primary scales in the lateral line, about 12-13 in a transverse series from lateral line to dorsal fin, and 13-14 between lateral line and anal fin. Body very wide, its width about 51-55 per cent of

the length without caudal fin in specimens of the size here described. Gill-raker rather short, only 5 in the lower, and 5-6 in the upper half of the first arch.

D. 77. A. 61. Left pectoral about 21-22 per cent, right pectoral 14-15 per cent of length without caudal fin.

DISCUSSION: Of this species the writer has only seen four specimens, the two included in the type sample, which was collected off the coast of Florida at a depth of 21 fathoms, and the two obtained by the "Albatross" in 95 fathoms off Cape Fear (33° N., 77° W.), all measuring between 85 and 100 mm. exclusive of the caudal fin.

***Citharichthys microstomus* GILL**

Citharichthys microstomus Gill, Proc. Acad. Nat. Sci. Philadelphia, Vol. XVI, 1864, p. 223.

Citharichthys micros Fowler, Proc. Acad. Nat. Sci. Philadelphia, Vol. LXIII, 1911, p. 200.

GENERAL DESCRIPTION: Mouth small, maxillary barely extending very slightly beyond a parallel with the axis of the body drawn through the ventral margin of the left orbit, its length about 5.7-6.8 per cent of the total length without caudal fin. The relative size of the eyes decreases very markedly with growth, as shown in the accompanying diagram (fig. 4), their diameter in specimens of less than 30 mm. length without caudal fin varying between 7 and 9.3 per cent of the latter measurement; while all specimens over 60 mm. showed eyes of less than 6.5 per cent diameter. Snout short, 4-5 per cent. Head 21-26.5 per cent, rather flat, with the interorbital ridge only moderately elevated, much less so than in *C. rimosus*, but somewhat more than in the other species. Snout with small, ctenoid (see figure 5), but not specially modified scales, passing from the interorbital space along the anterior margin of the left eye in a single series to form a triangular group between maxillary, nostril and eye; in a double row along the right eye, gradually expanding forwards to fill the space between nostrils, eye and profile of snout, without quite reaching to the upper lip. About six or seven primary rows of scales on the left cheek, between left orbit and preopercular margin, the count being rendered difficult, however, by the secondary squamation which partly obscures the arrangement of the primary scales in this region. Gillrakers few, short and stubby, 4 in the upper half of the first arch and normally only 5 in the lower, although 7 have been found in the latter section in the isolated case of the largest female specimen examined. The relative width of the body shows a very marked increase with growth, as already illustrated in the diagram on page 5. At a length without caudal fin of less than 40 mm., the width varies between 35 and 45 per cent of the former measurement, while above 70 mm. the range of variation is between 40 and 50 per cent, only in one single case, however, did the width attain

fully to the latter proportion. About 39-45 scales in lateral line, about 11-13, usually 12, between lateral line and dorsal fin, and about 13-16 between lateral line and anal fin. The anterior half of the free portion of each primary scale in adult specimens covered by secondary squamation in a fairly regular arrangement (see figure 5). The secondary scales apparently develop later and more slowly than the primary ones, and are therefore not very conspicuous in the smaller specimens. Primary scales microscopically ctenoid.

D. 67-81. A. 50-60. Left pectoral fin about 20-25 per cent, right pectoral 12-15 per cent of length without caudal fin.

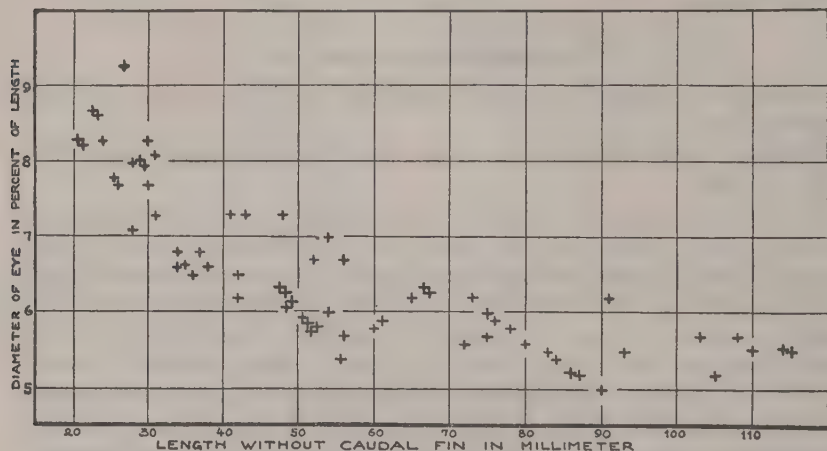


Figure 4. Correlation between relative size of the eyes and absolute size of the specimens in *Citharichthys microstomus*.

DISCUSSION: Although the author has not had opportunity to see the type specimen of *Citharichthys microstomus* Gill, it being neither included in the collections of the Academy of Natural Sciences in Philadelphia, nor in those of the United States National Museum, the identity of Dr. Gill's species with the form here described is quite unquestionable, and is further confirmed by numerous identifications of early and later dates in the U. S. National Museum, some of which may have been made by Dr. Gill himself. Fowler (1911, loc. cit., p. 202) in his discussion of the relationships of his presumably new species *C. micros* entirely fails to consider Dr. Gill's earlier description of the same form, as well as those of the most closely related other species (*C. etropus* and *C. rimosus*) while only comparing his material with the zoogeographically and morphologically more remote *C. arctifrons*, *C. unicornis* and *C. spilopterus*. For their description Gill and Fowler each have happened to obtain specimens showing opposite extremes in regard to the number of dorsal finrays, Gill recording 81

for *C. microstomus* and Fowler only 67 for "*C. micros.*" Neither of these figures were found by the present writer in the specimens examined in this respect, while, on the other hand, the complete range of variation between the said two extreme records, 68-80 dorsal rays inclusive, were counted. The author has therefore no hesitation in synonymising Fowler's species with *C. microstomus*, particularly not in view of the fact that both species were originally described

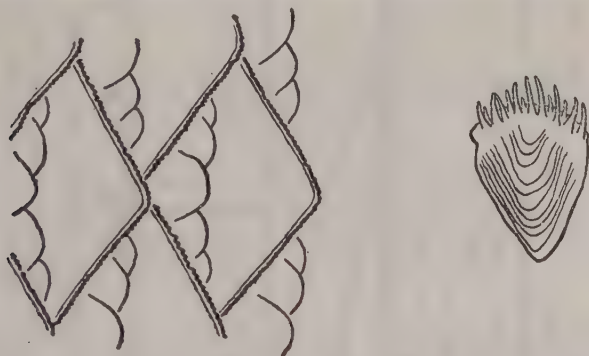


Figure 5. Primary and secondary squamation from the left side of *Citharichthys microstomus*, at left. Scale from the snout of the same species, at right.

from the same region (New Jersey) in which intensive collecting from the spring of 1929 to the date of publication has failed to reveal more than one single species, of which about fifteen hundred specimens have been obtained.

C. microstomus is very common in shallow water in the region of the Delaware Bay, its range, however, extending southward to Florida (one specimen in the U. S. National Museum) and northward to the New England coast (not north of Cape Cod?). Most abundant from 2 to 15 fathoms depth. Not observed in the tidal zone, nor beyond 25 fathoms. Maximum lengths seem to fall between 110 and 120 mm. without caudal fin.

***Citharichthys crossotus* (JORDAN and GILBERT)**

Etropus crossotus Jordan and Gilbert, Proc. U. S. Nat. Mus., Vol. IV, 1881, p. 364.

GENERAL DESCRIPTION: Mouth small, maxillary not extending noticeably beyond a parallel with the axis of the body drawn through the ventral margin of the left orbit. Maxillary short, 4.8-7.9 per cent of the total length without caudal fin, being relatively shorter in the older specimens. Snout shorter than eye, about 3.5-4.5 per cent of length without caudal fin; without spines or protuberances. Eyes about 6-7.5 per cent of the same measurement in specimens of about 40 to about 60 mm. length without caudal, and about 4.3-

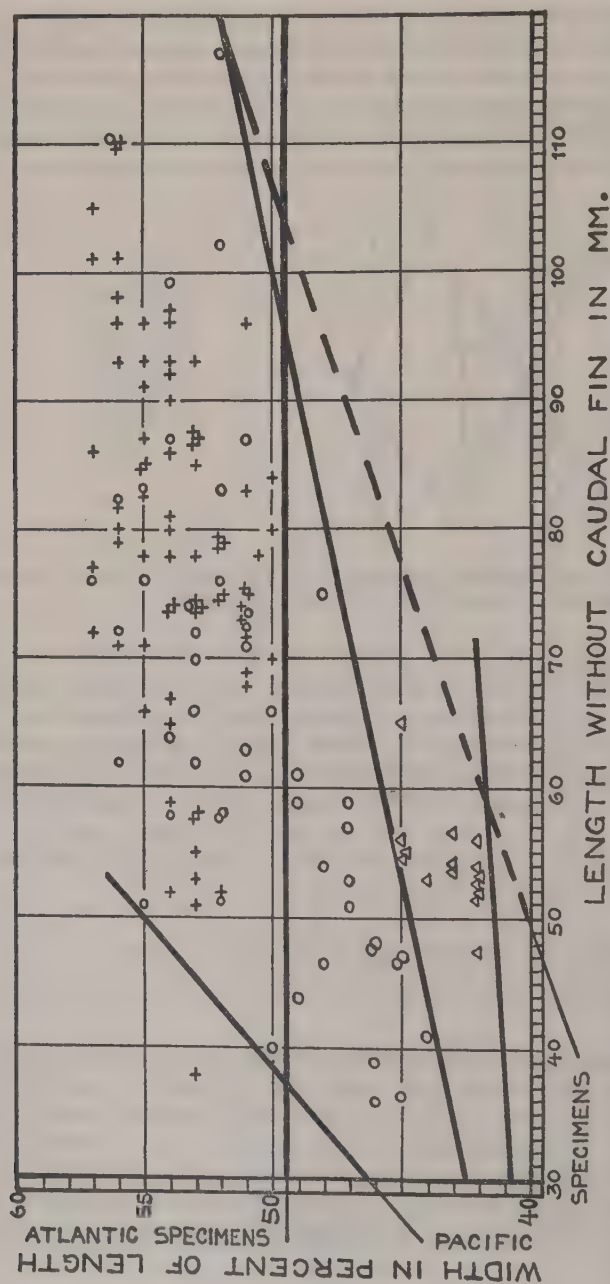


Figure 6. Correlation between relative width of the body and absolute size in *Citharichthys crossotus atlanticus* (crosses) and in the Pacific material of the same species (circles and triangles). The lower boundary for *C. c. atlanticus* is shown as a solid horizontal line, the boundaries for the Pacific material, as a whole, being represented by the upper solid oblique, on the left, and by the lower broken oblique, on the right. The lower two solid obliques serve to show where the differentiation of a third, slenderer subspecies, indicated by triangles, might seem possible.

6.0 per cent in the larger specimens. Head moderate, 20–28 per cent of length without caudal fin; generally, but not always, larger in the smaller specimens, less than 25 per cent of the length in all specimens over 90 mm. without caudal fin. Head flat, with only a slightly elevated interorbital ridge. Scales entirely absent from the snout, the squamation terminating at the anterior end of the interorbital space, well behind the posterior nostril and the line connecting the anterior margins of the two eyes. About 7–8 rows of scales between the left orbit and the preopercular margin. Gillrakers of moderate length, about 6–9 (usually 7 or 8) in the lower half and 4–6 in the upper half of the first arch. Body very broad in the adults, its width in fully grown specimens exceeding 50 per cent of its length exclusive of the caudal fin. Left pectoral fin about one fourth to one half longer than the right; both being small.

About 41–47 scales in the lateral line, 12–20 in a transverse series from lateral line to dorsal fin, and 14–20 in a similar series to anal fin, the transverse counts being made where the width of the body is greatest. Scales microscopically ctenoid. No secondary squamation.

D. 77–83. A. 60–64.

DISCUSSION:Flounders concordant with the above general description of *C. crossotus* appear to be very abundant on both coasts of Central and southern North America and have heretofore simply been gathered under the said specific designation, without any further taxonomic distinction between the Atlantic and Pacific representatives of this nominal species having ever been attempted. Being *a priori* inclined to regard as rather improbable such a perfect identity between the populations of two different regions, as completely separated from each other as in the present case, particularly in regard to benthonic shallow water forms such as the flounders here considered, the writer has made a considerable effort to discover any morphological differences between the Pacific and Atlantic samples which might allow of a specific distinction between the populations of the two oceans. In this endeavor only partial success can be claimed, however, inasmuch as the writer is still unable to differentiate the fully grown specimens of the two regions, while it has, on the other hand, been possible to show that there is a considerable and significant difference in the ontogenetic development of the body width. The accompanying diagram (fig. 6) illustrates the relative widths of the body in 73 Atlantic specimens and in 65 specimens from the Pacific. While the former show only the very slightest indication of a gradual increase in relative width with increasing size (see also p. 4 and fig. 1), the width being even in the smallest specimens observed more than 50 per cent of the length without caudal fin, the Pacific material, on the other hand, shows very marked and consistent differences in the relative width of the body over the same range of total lengths, the average widths in all groups of less than 60 mm. length without caudal fin being considerably less than 50 per cent of the latter measurement. In the

diagram the lower boundary for the observed values in the Atlantic samples is drawn as a solid horizontal line, the extreme boundaries for the Pacific specimens being represented by the solid upper oblique, and the broken lower oblique lines. It requires only a single glance at this illustration to realize the existence of an actual and significant difference between the populations of the two regions. Since, however, the feature involved does not allow of a morphological differentiation of the fully grown specimens it has not been considered advisable to carry the corresponding taxonomic distinction beyond the subspecific rank, but a new subspecific designation for the Atlantic form will be in its place, Jordan and Gilbert's description being based upon material from the Pacific (Mazatlan).

***Citharichthys crossotus atlanticus*, n. subsp.**

Relative width of body showing only the slightest indication of a gradual increase with increasing total length between 38 and 110 mm. length without caudal fin, the width having attained to about 50 per cent of the latter measurement, or more, already at the smallest of these sizes. Inhabitant of the tropical and subtropical western Atlantic shores. About 15-17 scales in a transverse series between dorsal fin and lateral line, and 14-17 between the latter and the anal fin.

Chesapeake Bay apparently represents the northern boundary of this subspecies, several specimens from that region being found in the collections of the U. S. Bureau of Fisheries, while not a single one was obtained by the writer in Delaware Bay although about 1500 *C. microstomus* were caught. From Chesapeake Bay southward, however, *C. crossotus atlanticus* seems to be fairly common all along the coast, and quite abundant in the proper environment along the shores of the Gulf of Mexico and the West Indies.

The largest size attained seems to be about 110 mm. without caudal fin or about 138-140 mm. total length, lengths between 70 and 100 mm. exclusive of the caudal being most frequently met with in collections.

***Citharichthys crossotus crossotus* (JORDAN and GILBERT)**

Relative width of body showing a very marked increase with increasing total lengths between 36 and 117 mm., exclusive of the caudal fin, the width being on an average distinctly and increasingly less than 50 per cent of the latter measurement in all groups with a length of less than 60 mm., as expressed in the same manner. Inhabitant of the tropical Pacific shores of America.

The largest specimen seen by the writer (No. 46427 U.S.N.M.) measured 191 mm. total length or 153 mm. without caudal fin, the width equalling 58 per cent of the latter measurement.

It seems quite possible, or even probable, that the group here provisionally

designated simply as *C. crossotus crossotus* may ultimately prove to be a complex of two separate subspecies, the smaller specimens in certain samples having been found to be more or less distinctly differentiable into a predominant group of the ordinary, comparatively wide form and a much less numerous group of more slender specimens. In the few cases in which the scales have been sufficiently well preserved for accurate counting the slender specimens show considerably lower transverse counts than do the wider ones, 12-13 between lateral line and dorsal fin and 13-14 between lateral line and anal fin being counted in the former, as compared with 17-20, and 16-20 in the latter. Intermediate counts (14-15, and 15-16) have, however, also been found in the Pacific samples; and the entire question as to the possible taxonomic significance of these differences must therefore be left for future decision by such investigators as may have opportunity to work on fresh and adequate collections from the Pacific. In the accompanying diagram the boundaries for the slender group of specimens as differentiated by the writer, have been indicated by the lower two of the solid oblique lines.

***Citharichthys unicornis* Goode**

Citharichthys unicornis Goode, Proc. U. S. Nat. Mus., Vol. III, 1880, p. 342.

GENERAL DESCRIPTION: Mouth large. The maxillary extends far beyond a parallel with the axis of the body drawn through the ventral margin of the left orbit, and quite or almost reaches to the continuation of a line through the centres of the two eyes, but not beyond this latter boundary. Length of maxillary approximately 11.5-13 per cent of total length without caudal fin; length of lower jaw 14-16 per cent of the same measurement. Eyes very large, 8.8-10 per cent of length without caudal, snout moderate, 4.5-7 per cent. Head large and very flat, except for the spines in the males, its length equalling about 28-29 per cent of the total length without caudal fin even in the largest specimens. About 7 rows of scales between the left orbit and the preopercular margin. The squamation of the snout varies with the sex. Gillrakers moderate, the largest only about one third of the length of the eyes, 12 in the lower half and 4-5 in the upper half of the first arch. Body moderately wide, its width about 39 to 48 per cent of the length without caudal, with only a slight tendency to increase between the observed lengths of 32 to 68 mm. (without caudal) as shown in the lower part of the accompanying diagram. Left pectoral fin generally less than one half longer than the right.

About 40 scales in the lateral line and about 12 in a transverse series from lateral line to dorsal fin and the same number (12) in a similar series to the anal fin. Scales microscopically ctenoid. Apparently no accessory scales.

D. 74-77. A. 60.

SECONDARY SEXUAL CHARACTERS: While the above general description applies equally well to both sexes the very pronounced secondary sexual differ-

ences in the species here considered necessitates a further discussion of the morphology of each sex separately, particularly in regard to the structures of the head.

While the juvenile males of less than 35 mm. length without caudal fin are hardly differentiable from the females, except by their internal anatomy, a

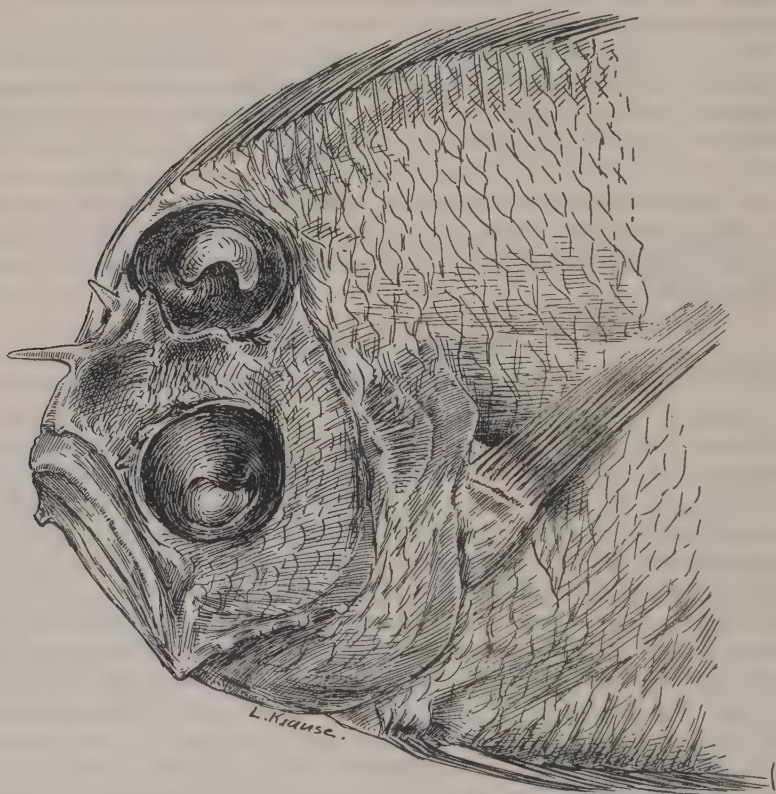


Figure 7. Head of an adult male of *Citharichthys unicornis*.

very conspicuous distinction soon develops in the rapidly increasing width of the interorbital space in the former sex while the eyes of the adult female remain as narrowly separated from each other as in the immature stages. These differences, and their gradual development, are illustrated in the accompanying figure 7 and in the upper part of figure 8.

Concurrently with this expansion of the interorbital space a great development of cephalic processes or spines takes place in the male. Most prominent

among these spines (see fig. 7) are: one projecting horizontally straight forward from the profile of the snout approximately in the median of the fish, one rising vertically (the flounder lying on its side) from the anterior portion of the mesial rim of each orbit, and a smaller one in the horizontal plane pointing obliquely forward, and to the side from the front of the right orbit. One or two

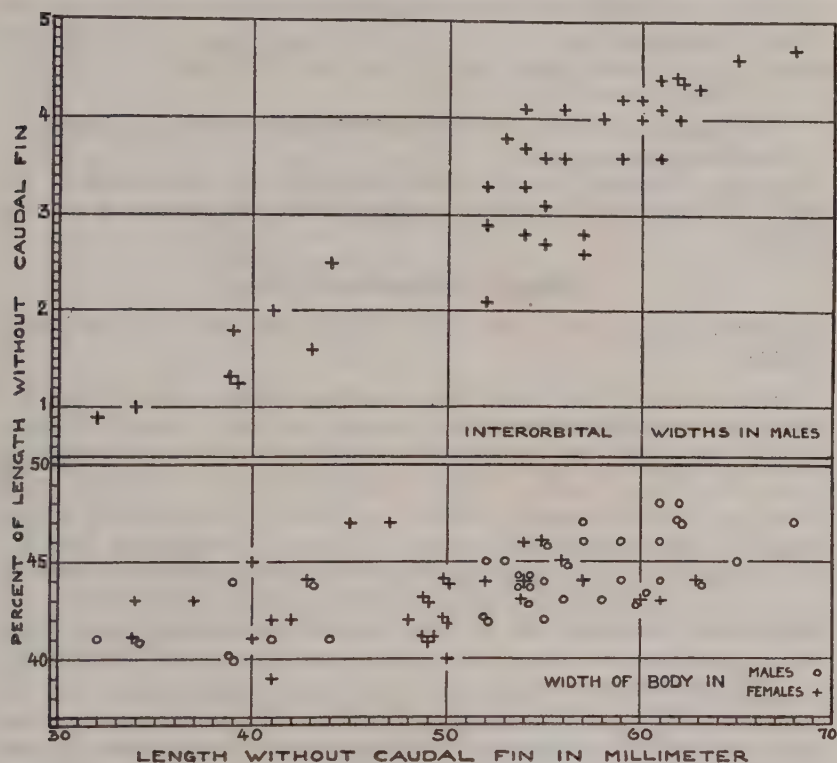


Figure 8. Correlation of relative interorbital width in males (above), and relative width of body in both sexes (below), with the absolute size of the specimens in *Citharichthys unicornis*.

minor vertical spines are generally also to be found along the anterior mesial rim of each orbit on either side of the larger one. There is a small forwardly directed spine on the snout at the anterior end of the maxillary groove and a pointed symphyseal projection from the lower jaw.

At a length without caudal fin of less than 40 mm. these various spines are merely indicated by slight and inconspicuous prominences, and they never develop beyond this stage in the female.

The squamation in the adult male extends forward of the anterior margins of both orbits in a band which may be several rows wide, particularly in front of the right eye. The squamation of the females, on the other hand, appears never to reach beyond the line connecting the anterior margins of the eyes.

It might be natural to suspect from the great difference in the widths of the heads of the two sexes that there would also be a conspicuous difference in the widths of their bodies, but this suspicion has not been confirmed by the measurements of the specimens studied by the writer, as will be seen from the lower part of the diagram rendered in figure 8.

A very small species, 65-70 mm. without caudal fin apparently representing the maximum length attained.

Very little is known about the actual abundance and distribution of this form which is generally recorded as occurring in "the deep waters of the Gulf Stream."

***Citharichthys macrops* DRESEL**

Citharichthys macrops Dresel, Proc. U. S. National Mus. Vol. VII, 1884 (1885), p. 539.

GENERAL DESCRIPTION: Mouth large, maxillary equalling about 10 per cent of the total length without caudal fin, extending far beyond a parallel with the axis of the body drawn through the ventral margin of the left eye, approximately to the vertical from its center. Snout only about two-thirds of the diameter of the left eye, the latter equalling about 7 per cent of the total length without caudal fin. Head about 25-26 per cent of the same measurement, very flat. 4 or 5 small scales in the anterior expansion of the interorbital space between the diverging mesial margins of the two orbits, but apparently none in front of a line between the anterior margins of the latter. Snout without spines or projections. About 7 or 8 rows of scales between left orbit and preopercular margin. Gillrakers relatively long and fine, 13 in the lower and 6 in the upper half of the first arch. Body wide, about 51-52 per cent of the total length without caudal fin. Left pectoral about one-third longer than the right, which measures about 12 per cent of the length without caudal.

Scales relatively large, cycloid or very minutely ctenoid. No secondary squamation. About 41 scales in the lateral line, about 14 between lateral line and dorsal and about 16 between lateral line and anal fin.

D. 80. A. 56.

DISCUSSION: The above account is based upon the type of the species (No. 21500 U.S.N.M.) measuring 101 mm. to the base of the caudal fin. For further details the reader must be referred to the exceptionally thorough and intelligent original description rendered by Mr. Dresel. A smaller specimen in the collections of the U. S. National Museum (No. 43972), measuring only 51 mm. without caudal fin, shows the following proportions in per cent of the said measurement:

Length of head 27. Diameter of eye 8. Length of maxillary 12. It also has 14 gillrakers in the lower half of the first arch, with only 5 in the upper half; but is in all other respects perfectly concordant with the type.

Known from the coast of Florida.

Citharichthys spilopterus GÜNTHER

Citharichthys spilopterus Günther, Catalogue of Fishes, Vol. IV, 1862, p. 421.

Citharichthys cayennensis Bleeker, Compt. Rend. Acad. Sci. Amsterdam Vol. XIII, 1862, p. 6.

Citharichthys guatemalensis Bleeker, Nederl. Tijdschr. Dierk. 1864, p. 73.

Hemirhombus fuscus Poey, Synopsis Pisc. Cubensium. 1868, p. 406.

GENERAL DESCRIPTION: Mouth moderately large, maxillary equalling about 9.5–12 per cent of the total length without caudal fin, being crossed by a parallel with the axis of the body drawn through the ventral margin of the left eye approximately at the beginning of the last third or two-fifths of its length. Snout

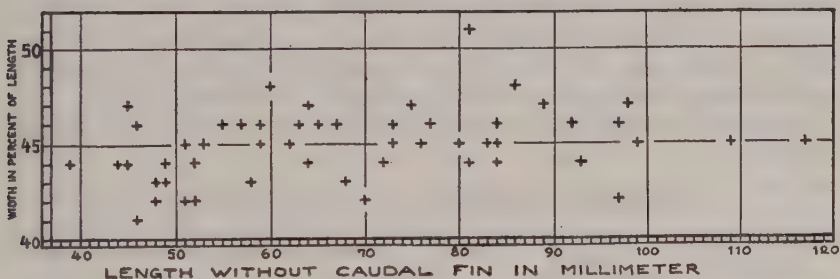


Figure 9. Correlations between relative width of body and absolute size of the specimens in *Citharichthys spilopterus*.

approximately equal to the diameter of the eyes, which is about 4.3–5.5 per cent of the total length without caudal fin. Head about 26–29 per cent of the same measurement, very flat, with the elevation of the interorbital space hardly appreciable. Snout entirely scale-less, and without spines or protuberances. About 12–15 rows of scales between left orbit and preopercular margin. Gillrakers rather short and stubby, about 10–11 in the lower half, and 4–5 in the upper half of the first arch. Body moderately broad, its width varying between 41 and 51 per cent of its length, apparently without any distinct increase with growth in specimens from 39 to 117 mm. long without caudal fin, as shown in the accompanying diagram (fig. 9).

Scales small, those on the left side finely ctenoid, those on the right almost smooth. About 46–49 scales in the lateral line, 15–18 between lateral line and dorsal, and 16–20 between lateral line and anal fin.

D. 79-82. A. 59-60. Pectorals small, left pectoral 15-16 per cent of length without caudal fin, right only 12.

DISCUSSION: *C. spilopterus* was first described from the Atlantic and appears to be very common in shallow water throughout the West Indian region and along the coasts of the Gulf of Mexico.

Pacific collections have subsequently been referred to the same species, and this identification has become generally accepted in the current literature. The writer has personally only had opportunity to examine two specimens of those recorded from the Pacific, Nos. 6223 and 41469 U.S.N.M. Of these it has been impossible to differentiate the former from the Atlantic material, but it may be worth mentioning that the specimen in question was collected by a seafaring captain whose donations to the U. S. National Museum entered between the serial numbers 2200 and 2300 (26 samples from the same donor) include material from such widely scattered points as California, Kamtschatka, Tahiti, Port Jackson, Hongkong, Hawaii and Madeira. A confusion of locality therefore seems possible. The other specimen, collected by the "Albatross," differs from the Atlantic form in several respects. (D. 88. About 43 scales in lateral line. 14 gillrakers in lower half of first arch). The question of taxonomic identity between the Atlantic and Pacific populations is therefore strongly in need of further investigation on Pacific material of indisputable origin.

The largest Atlantic specimen seen by the writer measured 117 mm. without caudal fin.

***Citharichthys arenaceus* EVERMANN and MARSH**

Citharichthys arenaceus Evermann and Marsh, Bull. U. S. Fish Comm., Vol. XX, 1900, pt. I, p. 326, fig. 106. (1902.)

GENERAL DESCRIPTION: Mouth very large; maxillary about 11-12 per cent of total length without caudal fin, being divided into approximately equal halves by a parallel with the axis of the body drawn through the ventral margin of the left eye. Eyes small, only about 4-4.5 per cent, snout longer, 5-6 per cent of the total length without caudal fin. Head rather large, about 28-29 per cent of the same measurement, and very flat, with the interorbital space only slightly elevated. No scales on the snout, the interorbital squamation ending approximately between the centres of the eyes. About 12-13 rows of scales between the left orbit and the preopercular margin. Gillrakers relatively long and slender, about 14 in the lower half and 6-7 in the upper half of the first arch. Snout without spines or protuberances. Body wide, its width usually more than 50(50-55) per cent of the length without caudal fin in fully grown specimens. Scales small, ctenoid at least on the eye-side, those on the blind side being almost smooth. Secondary scales present or absent, occurring most commonly in the region around the lateral line and usually only in the form of one single secondary scale over each primary one. About 50-52 scales in the

lateral line, about 18 between lateral line and dorsal and about 20 between lateral line and anal fin.

D. 68-75. A. 48-54. Pectorals small, length of left pectoral fin only about 14-15 per cent of length without caudal, right pectoral about 12 per cent.

DISCUSSION: A shallow water form, known only from Porto Rico and Santo Domingo. Reaches a length of at least about 140 mm. without caudal fin.

***Citharichthys uhleri* JORDAN and GOSS**

Citharichthys uhleri Jordan and Goss, Rep. U. S. Fish Comm., 1886 (1889), p. 275.

GENERAL DESCRIPTION: Mouth large, maxillary about equal to 10 per cent of the total length without caudal fin, being divided into two approximately equal parts by a parallel with the axis of the body drawn through the ventral margin of the left eye. Snout about equal to the eyes, or about 5 per cent of the length without caudal. Head about 26 per cent of the same measurement, very flat, with only a very slightly elevated interorbital ridge. Snout scaleless but for a few minute scales along the mesial halves of the anterior margins of the orbits. About 13-14 rows of scales between the left orbit and the free preopercular margin. About 5 gillrakers in the upper part and about 13 in the lower part of the first arch. Body broad, its width exactly 50 per cent of the length without caudal fin in the type specimen. Left pectoral fin about 15 per cent of the same measurement, right pectoral somewhat shorter.

Scales small, about 53-55 in the lateral line, about 15-16 between lateral line and dorsal fin and about 20-21 between lateral line and anal. Scales finely ctenoid. No secondary squamation.

D. 68. A. 52.

DISCUSSION: Only known from the type specimen, 110 mm. total length, 88 without caudal fin (No. 11102 Museum of Comparative Zoology), collected on the coast of Haiti.

SUMMARY AND CONCLUSIONS.

1. The unsatisfactory state of the present system of classification is discussed and the desirability of a world wide revision pointed out. The scope of the present article is, however, of necessity confined to the presentation of a practical instrument for the identification of the various species occurring along the Atlantic coast of North and Middle America, only, and these species have therefore all been provisionally retained within one single genus.

2. Important changes in body-proportions with growth are pointed out and their taxonomic significance considered.

3. A key, and descriptions of all species occurring along the Atlantic coast of North and Middle America, are rendered.

4. *Citharichthys micros* FOWLER is synonymised with *C. microstomus* Gill.

5. Significant differences in the development of the Atlantic and of the Pacific forms of *Citharichthys crossotus* JORDAN and GILBERT are pointed out, and a new subspecies, *atlanticus*, is introduced.

7. The possibility of two separate forms still being confused in the Pacific *Citharichthys crossotus crossotus* is suggested.

8. The desirability of a confirmation of the Pacific localities for *Citharichthys spilopterus* and the possibility of confusion in the previous records are pointed out.

A REVISION OF THE GENUS GOBIONELLUS (FAMILY GOBIIDAE)*

BY ISAAC GINSBURG
U. S. Bureau of Fisheries

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INTRODUCTION

There is a small and very common goby on the Gulf Coast which I collected in considerable numbers in the vicinity of Grand Isle, Louisiana, during the summer of 1930. While doing the field work I had the idea that being so common the species must be well known and resting on a solid foundation taxonomically. However, when working up my material by using current accounts, I encountered considerable difficulty in trying to decide the proper name which rightfully belongs to this common species. The difficulty was not so much that I could not find a description which would fit my fish, it was rather that too many accounts of species currently recognized would apply to it. The original descriptions of *Gobius boleosoma* and *Gobius encaeus*, two species which are generally recognized as distinct, fitted my fish fairly well; while those of *Smaragdus stigmaticus* and *Gobius shufeldti* were such as to suggest that they may possibly relate to it. Accounts by later authors were still more confusing, if anything. The problem was then to decide which one, if any, of these names is the rightful one for this very common species. In trying to solve this problem, I have examined the available material of all related species in the collections of the U. S. National Museum and the Bureau of Fisheries, supplemented by material in the Museum of Comparative Zoology, the Zoological Museum of the University of Michigan, and the Field Museum of Natural History as well as my own collections.¹ Enough data were thus accumulated that may serve as a badly needed revision of this genus which contains more species than any other genus of gobies in American waters. Since the systematics of the American *Gobiidae* is now in a very unstable condition, to say the least, the present comparative study of the genus containing the most numerous species, should go a long way in placing the American fishes of this family on a firm foundation taxonomically.

This study has shown that *encaeus* is a synonym of *boleosoma*, while *stigmaticus* and *shufeldti* are distinct. The data supporting these conclusions as well as the essential characters separating these and the other related species are presented in the following account.

The style of presentation used in this paper is somewhat different

¹ The courtesy of the officials of these institutions in allowing me the use of their material is gratefully acknowledged. I am especially thankful to Mr. William C. Schroeder of the Bureau of Fisheries who supplied me with some measurements and detailed notes of critical specimens in the Museum of Comparative Zoology.

from the conventional. The proportional measurements are given in tabular form expressed as percentages of the standard length, instead of giving the extremes as so many times in the head or the standard length. This is done because the proportions vary with age and also with sex, especially in the case of the caudal, consequently when only a few specimens are measured as must necessarily be done in a work of this kind, the tabular form is more useful because it shows the changes due to sex and age. When all measurements for each specimen, are referred to a common standard, the ratio of any two parts may easily be obtained by a simple division of the figures in the table. A close study of the tables of measurements shows that, with the exception of the caudal, the proportional lengths of the other parts, do not differ saliently between the species. While some species evidently have characteristic modes in such measurements as the relative length of the head, maxillary, and depth of body; these characters are also evidently overlapping, and unless the frequency distribution, by size groups, is worked out such relative measurements are not of much use. A mere statement of the range in proportional measurements of a few specimens, irrespective of size, would usually be more confusing than illuminating, and in any case would not be of appreciable practical value. There are some significant differences between the adults of those species which have inordinately long, drawn out bodies and those of more normal shape; but even in the long bodied species the difference in proportional measurements with age, are nearly as great as between the species with short bodies and those with long bodies. Consequently, conventional descriptions based chiefly on proportional measurements, irrespective of the frequency distribution, by segregated size groups, is hardly of any value in the practice of identification.

Method of measuring.—In the following tables the measurements given are as follows: Standard length, from the tip of the snout, on the surface of its fleshy lip, to the end of the hypoural, given in millimeters. The other measurements are expressed as percentages of this length: Caudal, from its tip to the end of the hypoural. Depth, the greatest depth of the body, pressed to approximately normal condition when necessary. Peduncle, the least depth of the caudal peduncle. Head, from tip of snout to posterior bony margin, not including the soft border. Eye, measured externally between the soft margins. Interorbital, the bony part, this measurement being

only approximate and is especially apt to be inaccurate in the smaller specimens, since the fleshy part on either side of the bone interferes with an accurate measurement. Snout, from tip of upper jaw on the surface of the fleshy lip to anterior soft margin of eye. Maxillary, from tip of upper jaw, as in snout measurement, to posterior border of maxillary. Postorbital part of head, from posterior soft margin of eye to posterior bony margin of head. Antedorsal distance, from tip of snout to origin of first dorsal. Ventral, from its origin to its posterior border; the former point being difficult to determine and will no doubt vary with the observer. Ventral to anal, from origin of former to origin of latter. A comparison of the last two measurements will show the relation of the posterior margin of the ventral to the origin of the anal. Pectoral from its base to its posterior margin, the first point being hard to localize exactly. All measurements were made with a Vernier caliper to a tenth of a millimeter.

Length of caudal fin.—The proportional length of the caudal is of much diagnostic value in distinguishing the species of this genus, if proper distinction is made between the sexes and the age of the specimen is taken into consideration. The caudal is always considerably shorter in the female and is much shorter in the young of either sex. Consequently when two species are compared for this character, the specimens must be of the same sex and of approximately the same size. The practical use of this character is rather limited, because the caudal is frequently more or less broken at the tip. In the tables of measurements as well as in the diagnoses only unbroken caudals were included, as determined by an examination with a binocular microscope. When the caudal as thus determined was nearly complete, but somewhat frayed at the tip, it is stated in parenthesis in the tables of measurements.

GOBIONELLUS.

Gobionellus Girard, Proc. Acad. Nat. Sc. Phila., p. 168, 1858. Genotype: *Gobionellus oceanicus* (Pallas) = *Gobius lanceolatus* Bloch by subsequent designation.

Gobionellus Bleeker, Arch. Neerland. Sc. Nat. 9: 325, 1874. (Esq. Gob. p. 37.) *Gobius lanceolatus* Bloch designated as genotype.

Gobionellus Jordan and Gilbert, Bull. U. S. Nat. Mus. 16: 635, 1883. *Gobius lanceolatus* Bloch designated as genotype.

The species comprising this genus have been kicked about like footballs between various genera by different authors, and it becomes necessary to point

out the pertinent characters which they have in common separating them off as a group of generic rank. They have most commonly been placed in *Gobius*. The type of the latter genus is *Gobius niger* which has the upper rays of the pectoral not connected by membrane, a character not present in any of the species treated here. From *Rhinogobius* and *Ctenogobius*, two other generic names which have been applied to some of the species, they may be separated by the relative number of rays in the second dorsal and anal, the present group of species having one more ray in the anal than in the second dorsal, except as an infrequent individual variation, whereas in the above two genera (which are possibly synonymous) the anal generally has a smaller number than, or an equal number to, the second dorsal. This last character applies also with respect to *Gobius*. The absolute number of rays is also generally greater than in *Rhinogobius*. The species of *Gobionellus* generally have a more or less elongated caudal especially in the male, the caudal reaching extreme proportions in the peripheral species. This character is shared by the genus *Oxyurichthys* from the Pacific, to which the extreme species of the present genus approach closely, but are separable by the character of the dentition of the upper jaw—a single row in *Oxyurichthys*, more than one row in *Gobionellus*.

The characters enumerated above seem too trivial for generic differentiation, but they are characters which hold true to a greater or lesser extent and serve to set off this group of species from related fishes. In the present family the separation of genera is now largely impossible without the use of just such "trivial" characters. Due either to convergent evolution, to too recent speciation or to other evolutionary phenomena, the species of this family run gradually into one another and unless such characters are used, we would almost have to go back to the Linnean conception of a genus. To a certain extent genera in the Gobiidae must be used to indicate trends of evolution, in so far as our present state of knowledge of their anatomy permits it; since the lines between genera can not be drawn boldly.

While on the one hand there is a tendency among some authors to lump a great many species under *Gobius*, there are writers who go to the other extreme and subdivide the species minutely into a great many genera. Within recent years a number of European investigators have studied the details of distribution of the mucous canals and the rows of cutaneous papillae in various species of gobies, by treating their material with special reagents to bring out these structures more prominently; and genera have been based to some extent on such characters. Lately, Iljin (in *Trabajos Inst. Esp. de Oceanografia*, no. 2, 1930) has multiplied the number of genera of European gobies by using to a large extent small differences in the distribution of cutaneous papillae and mucous canals.

In this study, I am not so much concerned with the minute structure of the cutaneous papillae as with the practical problem of being able to readily differentiate the species. In the species comprising the present genus, the

distribution of the papillae as far as it may be determined without special treatment is fairly uniform and does not vary much with the species. In fixing the generic limits a middle course has been taken between the two extremes. In general, in attempting the generic subdivision of any higher group, expediency must be considered as well as natural phylogeny, the latter being at the present time speculative to a large extent. Expediency demands, on the one hand, that the great number of known species be divided into convenient genera and, on the other, that the number of genera be not unduly multiplied. A definition of the genus follows:

Teeth not notched, in more than one series in both jaws; outer row in upper jaw more or less enlarged in both sexes; in lower jaw of males the outer and inner rows are more or less enlarged, in females the band of teeth in lower jaw more subequal, the enlarged teeth being appreciably less pronounced than in male. Caudal fin of grown male more or less prolonged, more than $\frac{1}{3}$ of body length, nearly always lanceolate, in some species very greatly prolonged; in the female of some species it is almost rounded, but is usually prolonged although not as much as in the male. Second dorsal normally 11 to 16; anal normally 12 to 17 rays. Anal fin normally having one more ray than the second dorsal, except as an infrequent individual variation. First dorsal with 6 spines, rarely 7 or 5 as an individual variation, the two dorsal fins separated. Body scaly, scales more or less ciliated especially on posterior half of body. Back in front of dorsal either entirely bare or more or less scaled. Cheeks and opercles scaleless, except in *oceanicus* and *hastatus*. In adults, maxillary usually somewhat longer in males, but never reaching much beyond posterior margin of eye. Broad low keel in front of dorsal, but no sharp crest. Tongue truncate or but slightly and broadly emarginate. Shoulder girdle without flaps. All rays of pectoral connected by membrane. No barbels. Ventrals free, well developed, completely united, interspinal membrane well developed. Anal papilla of male rather slender, comparatively long and pointed; that of female shorter and usually bulbous.

The principal rows of cutaneous papillae and the mucous canals, in so far as they may be seen without special treatment may be described as follows: Five cross rows of papillae under eye, more or less incomplete, the first two generally before angle of mouth and either one or both more or less oblique, posterior three rows nearly vertical; two longitudinal rows on cheek, usually more or less incomplete; two broadly rounded, parallel and closely approximated rows at lower angle of preopercle, continued forward nearly to a level through angle of mouth and but a short distance upward along vertical limb of preopercle; the inner row consisting of much coarser papillae; a vertical row near anterior margin of opercle, sometimes another near its posterior margin, two longitudinal rows on opercle, above and below, usually more or less oblique; a horizontal row behind eye, directly over opercle, usually continued backward a little beyond base of pectoral; a short row parallel to and on inner

side of lower jaw; a horizontal mucous canal behind eye at about a level through its middle, usually having three prominent pores, one directly behind eye, and one each at upper anterior and posterior angles of opercle, this canal apparently interrupted over opercle in some species, and apparently in all species continued upward and forward, curving along margin of eye to a prominent pore located at upper margin of eye and at a vertical through its anterior quarter or third; another prominent pore at upper nostril; more or less prominent pores present in depression between cheek and opercle apparently leading to a transverse mucous canal. The above description applies more or less to all the species, and is consequently not repeated under each species, but the more marked specific divergences are noted below under each species.

SEXUAL DIFFERENCES: In order to identify the species of this genus correctly, it is important to distinguish between the sexes, since sex characters may be mistakenly considered as specific. As a matter of fact, they have been so treated in some accounts. Fortunately, this may be done readily by an external character without dissecting out the gonads, and that is the shape of the anal papilla. In the male it is in the form of an elongate, pointed and compressed flap, while in the female it is mostly in the form of a fleshy bulbous tubercle, and when compressed it is considerably broader, shorter and less pointed than that of the male. The difference is even more marked in preserved specimens, since in such females the tubercle-like papilla is sunk by contraction and hardly projects above the surface of the belly. After one becomes familiar with this character, the sexes may be readily separated except in the very small fry. The only difficulty I found was with but a few specimens of *oceanicus*. The other characters which vary with sex are as follows. The caudal fin is always relatively longer in the male than the female. The posterior rays of the dorsal and anal are frequently relatively longer in the grown males. The same is true of the ventral disc. The elongation of the spines of the first dorsal is a sex character in some species but not in others. Some of the teeth of the lower jaw are more or less enlarged in the male, less so in the female. The maxillary, as a rule, is relatively somewhat longer in the male. The color pattern is the same in both sexes, but the male frequently has the pigment more intensely marked. The caudal in the male generally loses its streaked appearance and becomes more or less uniformly dusky with age.

Key to the Species.

1. Scales large or medium in about 29 to 46 oblique rows from base of pectoral to base of caudal. Dorsal rays normally 11 or 12. Anal rays normally 12 or 13.....2.
1. Scales small in about 59 to 89 oblique rows. Caudal very elongate, especially in male. Antedorsal area covered with scales for a variable distance. Dorsal rays normally 13 or 14. Anal rays normally 14 or 15.....8.

2. Second dorsal and anal normally with 12 and 13 rays, respectively¹.3.
2. Second dorsal and anal normally with 11 and 12 rays respectively.7.
3. Area in front of dorsal completely covered with scales as far as line through margin of preopercle; scales in front of dorsal cycloid but not much reduced. Caudal fin not greatly prolonged. Anterior three spots on body have diffuse bars extending downward and slightly forward. Shoulder spot not distinct*stigmaturus*.
3. Mid back in front of dorsal naked or when scales are present (in *shufeldti*) they are much reduced and few in number, not more than 5.4.
4. A few reduced scales present on mid back in front of dorsal; spines of first dorsal in male not greatly prolonged; no canine tooth on side of lower jaw.*shufeldti*.
4. No scales on midback in front of dorsal on surface of skin, sometimes one or two embedded scales present in large individuals.5.
5. Spines of first dorsal of male becoming excessively elongate with age, reaching to base of sixth to last ray of second dorsal in males over 50 mm. standard length, sometimes also in females. Size medium reaching to total length of about 80 mm. Atlantic Coast.6.
5. Spines of first dorsal not excessively elongate, not reaching past base of third ray of second dorsal. Size small, not known to be longer than 43 mm. Pacific Coast.*manglicola*.
6. Canine tooth on side of lower jaw absent, sometimes a small caninoid is present. Caudal shorter, not more than 43% in male, not over 37% in female. Ventral somewhat longer, usually about attaining to anal origin in males and to vent in females. Scales in about 36 to 43 oblique rows, modally 39. Shoulder spot absent. No vertical bars on cheek.*claytonii*.
6. Canine tooth on side of lower jaw present, very strongly marked, conspicuously larger than in any species of its genus. Caudal rather long, as much as 52% of body length in large males, 47% in females. Ventrals somewhat shorter, usually falling conspicuously short of vent in both sexes. Scales in about 31 to 36 rows. Shoulder spot usually present and well marked. Cross bars on cheek usually distinct.*stigmaticus*.
7. Antedorsal distance entirely naked, at least on the surface of the skin. Caudal not over 47%. Scales 29 to 33.*boleosoma*.
7. Scales present in front of dorsal. Caudal in grown male about 71%. Scales 39 to 46.*smaragdus*.

¹ While the character of the fin ray count will not separate the individual fish absolutely, a study of table 1 will show the high degree of uniformity and the small amount of intraspecific variation in the species comprising this genus, with respect to this character. It is as uniform as any single variable character may reasonably be expected to show. The fin ray count will separate individual fish belonging to species differing in that character, in over 90% of the cases.

8. No scales on opercle and cheek. Second dorsal and anal normally with 13 and 14 rays respectively.....9.
8. A patch of scales on opercle present; a few more or less embedded and non-imbricate scales present on cheek. Second dorsal and anal normally with 14 and 15 rays respectively. Back entirely covered with scales to within a short distance behind eyes. No shoulder spot. A large oval spot over midline at about level of middle of pectoral.....10.
9. Dorsal spine not filamentous in either sex, hardly extending past origin of second dorsal. Scales on back extending to about level of preopercle. Outer row of teeth in upper jaw strikingly enlarged in both sexes. Spots along midline longitudinally elongate, especially marked in young. Shoulder spot present, rather diffuse.....*sagittula*.
9. Dorsal spines filamentous (females only examined), the third spine reaching to base of fourth to sixth ray of second dorsal. Scales extending nearly to eye. Outer row of teeth in upper jaw of female but slightly enlarged. Spots on side of body transversely elongate, strikingly so in young. No distinct shoulder spot.....*microdon*.
10. Scales less numerous, in about 61 to 76 oblique rows from base of pectoral to base of caudal. Southern species.....*oceanicus*.
10. Scales more numerous, in about 76 to 89 oblique rows. Northern species.
hastatus.

TABLE 1.—Frequency distribution of the fin rays in the species of *Gobionellus*. The numbers in the body of the table represent frequencies. The first unbranched ray has been included in the count while the last two which are always approximated at their base have been counted as one.

Fin	First Dorsal			Second dorsal					Anal				
Number of rays (class)	5	6	7	10	11	12	13	14	11	12	13	14	15
<i>stigmaturus</i>		10				10					9		
<i>shufeldti</i>		24			1	19	4			2	21	1	
<i>claytonii</i>	1	24				24	1				25		
<i>stigmaticus</i>	1	23			1	24					25		
<i>manglicola</i>		3				3					3		
<i>boleosoma</i>		81		3	72	6			3	74	4		
<i>smaragdus</i>		4			4					4			
<i>sagittula</i>		12					12					12	
<i>microdon</i>		7				1	6					7	
<i>oceanicus</i>		30	1					31				1	30
<i>hastatus</i>		4						4					4

Gobionellus stigmaturus.

Gobius stigmaturus Goode and Bean, Pr. U. S. Nat. Mus. 5: 418, 1882.
(Southern United States.)

Gobius stigmaturus Jordan & Gilbert, Bull. U. S. Nat. Mus. 16: 946, 1883.
(Florida west coast.)

Gobius stigmaturus Jordan, Pr. U. S. Nat. Mus. 7: 140, 1884. (Key West.)

Gobius stigmaturus Jordan & Eigenmann, Pr. U. S. Nat. Mus. 9: 495, 1886.
(Florida Keys.)

Gobius stigmaturus Eigenmann and Eigenmann, Pr. Cal. Ac. Sc. (ser. 2) 1:
61, 1888.

Gobius stigmaturus Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2220,
1898. (Key West.)

Gobius stigmaturus Garman, Jr. Conn. Ac. Art. Sc. 10: 510, 1900. (Bermuda.)

Gobius stigmaturus Rosen, Acta Univ. Lund, N. F. Afd. 2, 7: 63, 1911. (Hog
Island, Bahama.)



Figure 1. *Gobionellus stigmaturus*. Drawn from a male, 41 mm. total length, from Key West, Florida, U. S. N. M. 89883. This and the other figures illustrating this paper were drawn by Miss Louella E. Cable of the U. S. Bureau of Fisheries.

D. 6-12. A. 13. Scales 29 to 33. Caudal in male 30 mm. standard length, 36%; in two females, 36 and 38 mm., 34% and 31%, respectively.

Mouth small, nearly horizontal, lower jaw included. Maxillary in male reaching to a vertical through about middle of eye, to anterior margin of pupil in female. Upper jaw of male having about 6 teeth of outer row, at the middle, much enlarged, caninoid, somewhat recurved; teeth behind outer row very small, lower jaw with a few teeth of inner row, at symphysis, rather enlarged, and one conspicuous caninoid in outer row, about midway between symphysis and angle of mouth. Teeth of female nearly the same; outer row of upper jaw not as much enlarged; those in lower jaw subequal except one conspicuous caninoid on side, not as large, however, as in male. Scales on sides ciliated to origin of first dorsal; in 29 to 33 rows from upper angle of base of pectoral to base of caudal; 9 to 10 scales in an oblique row from origin of anal to base of

second dorsal; area in front of dorsal entirely covered with cycloid scales to about the level of preopercle; predorsal scales rather reduced but not as much as in other species of this genus; chest and belly with scales, sometimes more or less embedded. Spines of first dorsal not reaching past origin of second dorsal in females, not past base of second ray in males. Posterior rays of second dorsal and anal usually just about reach procumbent rays of caudal in both sexes, but slightly shorter in female.

Body and head peculiarly marbled with pearly white and brownish. Five more or less diffuse spots along middle of body, the last one at base of tail; from the anterior 3 or 4 diffuse narrow bars are continued downward and slightly forward, this being quite characteristic of the species. Dorsals and caudal with streaks made up of rows of spots. A row of small splotches near bases of anal and second dorsal. Diffuse spots on cheek under the eye, from eye to upper lip, at angle of preopercle, on opercle, and one shoulder spot over angle of gill opening; these spots, however, usually of nearly the same intensity as the other marblings and are not saliently marked.

This is evidently a small species, the largest specimen examined being a female 47 mm. total length. Specimens in alcohol may usually be distinguished with readiness by the peculiar marbled appearance of pearly white and brownish. The color pattern is also distinctive, especially the diffuse short bars descending obliquely downward and forward from the median spots. The caudal is but moderately elongate. The structural features which serve to distinguish this species at a glance from related species in the same region are, 1.) large scales and 2.) the completely scaled nape. This combination is quite unlike any other species. The type could not be found, but Jordan and Eigenmann who state to have examined it, by their description of the scaling and the characteristic color marking enable me to place the species with assurance. In its squamation as well as the length of the caudal it approaches those species of *Rhinogobius* having scales in front of the dorsal, but the anal has one more ray than the second dorsal like the normal condition in the other species of the present genus. The absolute number of rays is also higher than is generally the case in *Rhinogobius*.

The present species probably has a restricted geographical range, being known chiefly from Key West, Florida, where it is fairly common and may be taken by seining the shallows. It has also been recorded from Bermuda by Garman, but his description is not sufficiently detailed to determine whether it refers to the same fish described herewith. Rosen does not give a description of his material from Bahama. The material recorded by Metzlaar from Curacao as *Gobius stigmaturus* (Bijdr. Dierk. Amsterdam, vol. 22, p. 138, 1922), most certainly does not belong to the present species, if his fin ray counts are correct. Barbour records as *Gobius stigmaturus* (Bull. Mus. Comp. Zool. vol. 46, p. 130. 1905), a specimen from Bermuda having 4 dorsal spines, which, if not a mis-

print, can not be the present species. The material examined in the National Museum all come from Key West.

TABLE 2.—Measurements of *G. stigmaturus* and *G. shufeldti*, expressed as percentages of standard length.

Part measured	Species						
	<i>G. stigmaturus</i>			<i>G. shufeldti</i>			
	(1) ♀	(1) ♀	(1) ♂	(3) ♀	(2) ♀	(4) ♀	(2) ♂
Standard length	31.2	34	30.2	42.5	49.2	61.2	53.4
Caudal (5)	30.5		36.4		(30.5)		(37.5)
Depth	23.4	22.9	19.9	17.2	22.0	21.4	24.3
Peduncle	10.9	10.9	11.3	8.9	10.0	9.1	10.3
Head	29.5	30.3	28.2	27.3	28.7	27.7	30.0
Eye	9.0	8.8	9.3	7.1	6.5	7.3	6.7
Interorbital	1.9	1.8	2.0	1.9	1.8	1.8	1.7
Snout	10.3	9.7	9.6	8.5	9.3	9.5	11.0
Maxillary	11.9	11.2	11.9	11.1	13.0	13.4	15.6
Postorbital	16.0	15.6	15.2	15.3	16.7	15.7	16.3
Antedorsal	36.2	37.6	33.8	34.3	37.6	35.2	36.5
Ventral	28.2	26.2	27.2	22.4	24.4		24.3
Ventral to anal	29.2	28.5	27.2	30.6	29.9	28.9	30.0
Pectoral	25.6		25.5	22.6			25.6

(1) Key West Florida. (2) From the cotypes, New Orleans, Louisiana. (3) Barataria Bay, Louisiana. (4) Dickinson Bayou, Texas. (5) Percentage of caudal placed in parenthesis signifies that it is frayed at the tip, although apparently nearly complete.

Gobionellus shufeldti.

Gobius wurdemanni Jordan, Pr. U. S. Nat. Mus. 7: 321, 1884. (New Orleans, La.)

Gobius shufeldti Jordan and Eigenmann, Pr. U. S. Nat. Mus. 9: 495, 1886. (New Orleans, La., based on same material as previous record.)

Gobius boleosoma Evermann and Kendall (in part) Bull. U. S. Fish Comm. 12: 117 (1892) 1894. (Dickinson Bayou, Texas. Reexamined.)

Gobius shufeldti Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2221, 1898. (New Orleans.)

D. 6–(11) 12 (13). A. (12) 13 (14). Scales 34 to 36. Caudal in one male, 53 mm. standard length, 38%. In two females 56 and 49 mm., 32% and 31%, respectively. (The caudal is very slightly broken at the tip in all three, these being the best available for measurements, but from their appearance it is evident that the portion broken off is almost negligible.)

Mouth low, somewhat oblique, rather large; lower jaw slightly included. Maxillary in a male of 71.5 mm. total length, reaching a vertical through posterior margin of eye, considerably past eye in two males 77 and 84 mm.; to posterior margin of eye in female 78 mm., not quite that far in smaller females. Upper jaw of male with some of middle teeth of outer row enlarged, recurved, and an inner band of smaller teeth, in lower jaw the band of teeth more nearly equal, the outer row hardly enlarged, except two or three teeth about midway between symphysis and angle of mouth which are more or less caninoid and recurved, two or three enlarged teeth in inner row near symphysis; in female outer row of teeth in upper jaw not much enlarged, comparatively smaller than in any related species, the band of teeth in lower jaw subequal, except a few in inner row which are but slightly enlarged in the largest individuals. Scales in about 34 to 36 oblique rows from upper angle of base of pectoral to base of caudal, 10 to 12 in an oblique row from origin of anal to base of second dorsal; scales ciliated on sides nearly, but not quite, up to origin of first dorsal on upper half

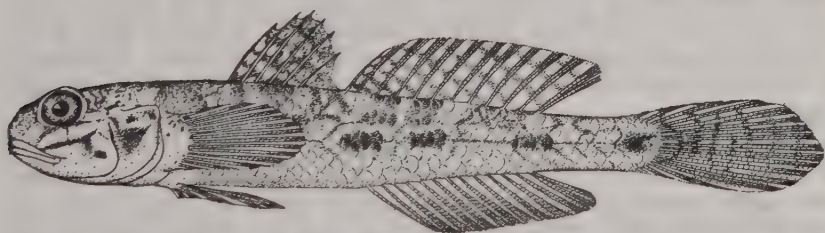


Figure 2. *Gobionellus shufeldti*. Drawn from a female, probably immature, 42.5 mm. standard length, taken in a seine on the beach, Razor Island, Barataria Bay, Louisiana (designated as Queen Bess Island on current hydrographic maps). The body of this specimen is conspicuously more slender than in the cotypes. The caudal is broken at the end and consequently its length represented by the figure is conjectural.

and to base of pectoral on lower; space over anterior half of pectoral covered with smaller cycloid scales to midline, a few scales in front of dorsal crossing over on midline, more or less embedded, but 2 to 5 scales always evident on surface of skin on midline, except in specimens of less than 40 mm.; chest apparently naked; belly covered with more or less embedded scales. Dorsal spines but little filamentous, hardly reaching past base of second ray of soft dorsal in males, not past origin of second dorsal in females. Posterior rays of second dorsal and anal reaching slightly past base of caudal in large males, usually not quite reaching to base of caudal in females. The cutaneous papillae in most of the specimens at hand are nearly obliterated, but in the few in which they are quite readily distinguishable their distribution is about as is typical for the genus.

Five diffuse blotches along middle of sides. Above and between these blotches irregularly marked with brown, the general color of the body resembling that

of *boleosoma*. No shoulder spot and no definite V-marks. Back in front of dorsal with anastomosing lines which may be broken up into small spots. An oblique dark diffuse band on cheek; a dark spot on opercle. Caudal and dorsal with rows of small spots. Pectorals and anal sprinkled with dusky. Ventral without color. An indistinct short bar below eye. The above color notes are based on two females, the males at hand being faded.

This is a medium sized species. The largest male examined 84 mm., largest female 78 mm. From *boleosoma* which is the most common species in the localities where *shufeldti* occurs, the latter may be distinguished by its larger size, the greater number of rays in the vertical fins; the shorter caudal; the lack of a definite shoulder spot and V-shaped marks on the body; and a somewhat greater extent of scaling in front of the dorsal fin, two to five rows of reduced scales being present on the midline in front of the dorsal.

The original types were obtained at New Orleans. Besides the cotypes the other material examined which extend the range of the species are: (1) A single female 54 mm. total length seined at Razor Island in Barataria Bay, Louisiana. (2) U. S. N. M. 59074, 8 specimens, 27 to 40 mm. total length, bears a label inside as follows: "Original label lost, Sampit River? Georgetown, S. C. Dec. or Jan. 1890 or 1891, W. C. Kendall." These specimens are placed under *shufeldti* largely on the basis of the fin ray count, since they are too small to show the characteristic appearance of that species. The rays are, D 12 A 13 in five specimens; D 13 A 13 in two and D 12 A 14 in one. This character is very unlike *boleosoma* the common species of the region, but it does agree quite closely with *shufeldti*. There is a possibility that these young specimens represent *claytonii* or *stigmaticus*, since I do not have sufficient material to enable me to consistently separate the young of these two species from *shufeldti*. However, it seems highly probable that the latter is a northern species while the other two are southern. Besides, the 40 mm. specimen already shows a couple of scales on the midline in front of the dorsal which is the normal condition for *shufeldti* and unlike *claytonii* or *stigmaticus*. The probabilities, therefore, favor the conclusions that these young fishes belong to the present species. (3) Two of the specimens from Dickinson Bayou, Texas, which have been recorded by Evermann and Kendall under the name of *G. boleosoma* are in the reserve series of the U. S. Bureau of Fisheries. One of them is undoubtedly an example of the present species.

Jordan and Dickerson (Pr. U. S. Nat. Mus. 34: 21, 1908) have recorded this species under the name of *Rhinogobius shufeldti* as occurring at Rio Panuco, Mexico. I have reexamined these specimens, U. S. N. M. 62292. They are quite small and somewhat faded, but some of them show the V-shaped marks and shoulder spot which are characteristic of *boleosoma*. Five specimens picked at random showed counts of D 11, A 12. There is hardly a doubt but that the lot represents the latter species, except one male in bad condition which is evidently a *claytonii*. The species under consideration is therefore known at

this writing only from the coasts of Texas, Louisiana and possibly South Carolina.

TABLE 3.—Correlation between the number of rays in the second dorsal and anal of *G. shufeldti*. The numbers in the body of the table represent frequencies. Note that the dorsal has at least one ray less than the anal, except in 5 specimens.

Anal rays	Dorsal rays		
	11	12	13
12	1	1	
13		17	4
14		1	

Gobionellus claytonii.

Gobius claytonii Meek, Publ. Field. Columb Mus., Chicago (Zool. ser.) 3: 121, pl. 31, 1900. (Rio San Francisco, Vera Cruz, Mexico.)

Gobius boleosoma, Eigenmann (in part) Bull. U. S. Fish Comm. 22: 236, 1903. (Rio San Juan, Cuba; specimens reexamined.)

Gobius fasciatus, Regan (not Gill) Pr. Zool. Soc. London, 1906, p. 392. (Trinidad.)

Rhinogobius shufeldti Jordan and Dickerson (in part) Pr. U. S. Nat. Mus. 34: 21, 1908. (Rio Panuco, Mexico.)

Gobionellus stigmaticus Meek and Hildebrand, Publ. Field Mus., Chicago, (Zool. ser.) 15: 882, pt. 3, 1928 (Panama).

D. (5) 6-12 (13). A. 13. Scales 35 to 43, modally 39. Caudal in 5 males 28 to 54 mm. standard length, 34 to 43%; in 12 females 33 to 52 mm., 32 to 37%.

Mouth not large, placed low, nearly horizontal; lower jaw somewhat included. Maxillary reaching to a vertical through posterior margin of pupil in male, to middle of eye in female. Upper jaw of male with the outer row having about 8 moderately enlarged teeth at the middle, and with an inner narrow band of smaller teeth; lower jaw with the outer row and a few at symphysis of inner row somewhat enlarged; usually no conspicuously enlarged tooth on side of lower jaw, sometimes a small caninoid is present. In female teeth are about the same as in male but enlarged teeth still less pronounced; a caninoid on side of lower jaw sometimes present, usually absent. Scales in about 35 to 43 rows from upper angle of base of pectoral to base of caudal; 10 to 12 in an oblique row from origin of anal to base of second dorsal. Scales on sides ciliated to origin of first dorsal, a few reduced, cycloid, more or less embedded scales in front of that. No scales in front of a line joining upper angle of base of pectoral and origin of first dorsal, at least on surface of skin; 2 or 3 embedded scales may be present in front of dorsal, on midline, in large specimens; top of head and nape naked;

chest naked; belly usually naked (more or less scaled in Panama specimens). Third spine of first dorsal very long and filamentous in males, reaching to base of eighth to tenth ray of second dorsal when laid back in specimen of 50 to 60 mm. total length, decreasing in length in smaller males; in larger females reaching only to about base of first or second ray. Posterior rays of second dorsal and anal just reach base of procumbent caudal rays in females, considerably past that in males.

Median line of body with 5 rather diffuse blotches, irregularly marbled and spotted with somewhat reticulating rows and group of minute spots above and between the median row of large spots; one to three diffuse bars under eye; on obliquely longitudinal diffuse streak across cheek; a diffuse blotch on cheek at lower angle of preopercle frequently present (in specimens from Panama); caudal and both dorsals streaked with rows of small spots; pectorals nearly uniformly sprinkled with melanophores, presenting a more or less dusky appearance; ventral colored similar to pectoral, but frequently more intensely dark along middle; anal in males usually dusky, becoming more intensely pigmented posteriorly, with a basal row of black specks frequently very conspicuous; anal in female with a light margin, the rest of the fin being sprinkled with melanophores, becoming more intensely dusky distad and posteriorly giving the appearance of a submarginal dark streak, sometimes having a basal row of dark blotches, more diffuse and larger than the basal row of black specks in the male. In old males the caudal and the anal tend to become uniformly dusky. Five specimens from Rio San Francisco or Boca del Rio, Vera Cruz, Mexico, are very dark all over; while three specimens from Rio Papaloapam are very light in color.

This species is close to *stigmaticus*, differing chiefly in the absence of a strong canine on the side of the lower jaw and in having a shorter caudal. The present species also has a somewhat more slender body, longer ventrals and somewhat smaller scales, but there is considerable intergradation in these characters. It also lacks a well defined shoulder blotch and vertical bars on the cheek, color marks which are more or less distinct in *stigmaticus*. But while the two species are evidently distinct and diverge conspicuously in a number of specific characters, they are yet very closely related and extreme individuals in both species approach one another closely, so that they are sometimes hard to place. This is especially true of some small individuals of the material examined, under 35 mm. in standard length in which the typical coloration has faded. The canine tooth of *stigmaticus* is relatively much smaller in the small specimens, while on the other hand, some specimens of *claytonii*, small as well as large, have a small caninoid. The other salient structural character differentiating the two species, namely, the relative length of the caudal, also is not so well marked in small individuals. Consequently, it may readily be seen why the smaller specimens are sometimes hard to place.

It is also close to *shufeldti*, but the latter species has 2 to 5 scales in front of

the dorsal, on the midline, visible on the surface of the skin; a larger mouth and longer maxillary, and the third spine is not notably filamentous in the three large males examined. From the very common *boleosoma* which the present species resembles somewhat, it may be differentiated by the normally greater number of fin rays, the extremely filamentous condition of the third spine in the male, the lack of a shoulder spot and its larger size.

Material from the following localities was examined: 1) Rio San Francisco, La Antigua, Vera Cruz, Mexico; Meek and Lutz; Field Museum of Natural History, 8 paratypes. 2) Rio San Francisco, San Francisco, Mexico, or Boca del Rio, Boca del Rio, Vera Cruz, Mexico, or both localities; Field Museum of Natural History, 5 specimens. These specimens are very dark all over, possibly due to the manner of preservation, but the normal color pattern is evident. The largest male of these has two well marked caninoids on the side of the lower jaw. 3) Rio Papaloapam, at San Cristobel, Vera Cruz, Mexico; Ostos, Creaser and Gordon; University of Michigan Zoological Museum. These three specimens are markedly light colored all over, lighter than any of the others examined, and two, one male and one female, have a small caninoid on the side of the lower jaw. 4) Rio Cascajal, Porto Bello, Panama, Meek and Hildebrand, U. S. N. M. 81819, three specimens. 5) Mindi Creek, Mindi, Canal Zool., Meek and Hildebrand, U. S. N. M. 81824, one specimen and 81875, five specimens. The fish from Panama differ in having the belly more completely scaled, in having a couple of rows of scales less, on the average, and in most specimens there is a rather inconspicuous diffuse blotch on the cheek, at the lower angle of the preopercle. They agree, however, in the other characters studied as well as in the color pattern and general appearance. As far as may be judged by the material examined, they belong to the same species as the preceding. Some of them have a caninoid on the side of the lower jaw. 6) Rio San Juan, Cuba, Eigenmann, U. S. N. M. 55695. This bottle is labeled *Gobius boleosoma* and is evidently the material recorded under that name by Eigenmann. It contains two specimens, one a true *boleosoma*, but the other is of a different species and appears to be an example of *claytonii*, although there is a possibility that it is *stigmaticus*, since it is too small and faded for positive identification. 7) Rio Panuco, Mexico, U. S. N. M. 62292. This bottle contains the material recorded by Jordan and Dickerson under the name of *Rhinogobius shufeldti*. It represents *boleosoma*, at least the greater part of it, as stated on p. 14, but one specimen. It is a male not in good condition. The third spine of the first dorsal reaches nearly to the end of the second dorsal, D 12, A 13. There is a fairly large caninoid tooth in the middle of the lower jaw, on the right side but not on the left. This tooth is, however, by far not as large as is typical of *stigmaticus*. The specimen is most probably an example of the present species.

The material recorded by Regan from Trinidad under the name of *Gobius fasciatus*, is probably the present species, as far as may be judged from the description. His assumption that Gill in describing *fasciatus* miscounted

the fin rays is unacceptable for two reasons. First, I have had the opportunity to examine some of Gill's material of various species in the National Museum, and find that he was in the habit of accurately recording fin ray counts. Second, gobies having the number of fin rays as stated by Gill are known to exist in the West Indies. As to which one of these is to be referred to Gill's species remains to be learned by an exact comparative study. Regan mentions in his description the presence of a curved canine in the lower jaw. This would apply more to *stigmaticus*; but the present species sometimes also has a caninoid tooth, and while the difference in size is readily appreciable on direct comparison, it is more or less a matter of degree which is hard to express absolutely in words. His description of the caudal and the color seems to apply more to the present species.

The species is, therefore, known at present from Vera Cruz, Mexico; the Atlantic coast of Panama; and possibly also from Trinidad and Cuba. It is a medium sized species. The largest specimen examined, from Vera Cruz, is a female 58 mm. standard length, 77 mm. including the caudal fin. Judging by the material at hand, it seems to be fairly common, probably more common than *stigmaticus*.

TABLE 4.—Measurements of *G. claytonii* and *G. stigmaticus*, expressed as percentages of the standard length.

Part measured	Species											
	<i>G. claytonii</i>									<i>G. stigmaticus</i>		
	(2) ♀	(3) ♀	(2) ♀	(1) ♀	(3) ♀	(1) ♂	(2) ♂	(3) ♂		(4) ♀	(5) ♀	(5) ♂
Standard length	34.4	37.3	40.0	40.1	49.4	28.1	35.5	42.8		37.6	54.3	47.6
Caudal	35.6	31.9	36.5	32.9	31.8	34.9	36.6			37.2	(42.7)	
Depth	19.8	18.8		18.2	20.0	17.8	18.9	18.2		20.7	20.3	19.5
Peduncle	9.6	9.9	9.5	10.0	9.7	10.0	9.1	9.6		10.1	10.5	10.5
Head	26.8	28.2	26.5	26.9	28.9	28.1	26.6	27.1		25.5	24.3	23.1
Eye	8.1	8.2	7.7	7.0	8.7	8.7	8.3	7.9		7.9	7.4	7.7
Interorbital	1.6	1.6	1.3	1.2	1.8	1.4	1.4	1.6		1.3	1.3	1.3
Snout	8.1	9.9	9.5	9.0	11.5	7.5	8.6	9.1		7.9	7.0	7.1
Maxillary	11.3	11.0	11.3	10.7	11.1	10.7	12.0	11.7		9.8	11.1	10.9
Postorbital	15.4	15.6	14.0	13.9	16.2	15.7	15.1	15.7		14.9	13.6	13.0
Antedorsal	34.0	35.1	36.5	34.7	35.4	37.4	33.4	33.6		35.4	33.2	32.8
Ventral	25.6	24.7	25.0	27.2	27.9	28.7	25.7	27.6		22.9	24.5	24.2
Ventral to anal	27.9	29.0	28.8	29.7	31.2	27.8	26.3	30.1		30.0	32.0	29.4
Pectoral	25.0	27.6	24.5	26.9	27.7	25.6	23.4	27.6		23.9	24.7	27.1

(1) Paratypes. Rio San Francisco, La Antigua, Vera Cruz, Mexico. (2) Rio Papaloapam, at San Cristobel, Vera Cruz, Mexico. (3) Mindi Creek, Mindi, Canal Zone. (4) Cuba. (5) Rio Janeiro, in poor condition.

***Gobionellus stigmaticus*.**

Smaragdus stigmaticus Poey, Memorias Hist. Nat. Cuba 2: 281, 1861. (Cuba.)

Gobionellus stigmaticus Poey, Rep. Fis. Nat. Cuba. 2: 394 (Synopsis), 1868. (Cuba.)

Gobionellus stigmaticus Poey, An. Sc. Esp. Hist. Nat. 5: 168 (Enumeratio, p. 126), 1876.

Gobionellus stigmaticus Jordan and Gilbert, Bull. U. S. Nat. Mus. 16: 947, 1883. (Southern Florida; Cuba.)

Gobius stigmaticus Jordan, Pr. U. S. Nat. Mus. 9: 49, 1886. (Cuba.)

Gobius stigmaticus Jordan and Eigenmann, t. c., p. 496, 1886. (Havana, Cuba; Florida.)

Gobius stigmaticus Eigenmann and Eigenmann, Pr. California Ac. Sc. (ser. 2) 1: 63, 1888. (Cuba; Rio Janeiro.)

Gobius stigmaticus Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2224, pt. 3, 1898 (except figure).

D. (5) 6-(11) 12. A. 13. Caudal in a male 46 mm. standard length, 52%. (This was the only male in which the caudal appeared to be entire); 7 females, 45 to 54 mm. standard length, with the caudal apparently entire or but slightly broken off at tip, 41 to 46%.

Mouth moderately oblique; lower jaw coterminous with upper, sometimes but slightly included. Maxillary reaches to vertical through posterior margin of pupil in both sexes, in specimens of about 50 mm. standard length. Teeth in narrow bands in both jaws. In male; outer row of upper jaw strongly enlarged, especially the front 8 or 10 being caninoid, recurved; lower jaw with markedly enlarged teeth in inner row near symphysis, outer row less markedly enlarged, except one very strong canine, situated about midway between symphysis and angle of mouth, stronger than in any species of the genus, strongly inclined to the horizontal, recurved outward, present in both sexes, most conspicuous in specimen over 40 mm. standard length, sometimes one or two smaller caninoid teeth next to it, one of latter infrequently subequal to the large canine. In female; teeth about same as in male, enlarged teeth not so marked, outer row of lower jaw hardly enlarged with exception of the above described strong canine, being about as large as in male. Scales in material examined incomplete, probably in about 32 to 35 rows from base of pectoral to base of caudal. Nape naked to origin of dorsal. Side of head and chest naked. Belly scaled. Scales ciliated to origin of spinous dorsal, only a few cycloid scales anterior to that. Spines of first dorsal filamentous, reaching in males 44 to 48 mm. standard length, to base of sixth to eighth ray of second dorsal when laid flat along the back; in majority of females of about like size reaching to base of first to third ray, in about one third of the females, 5 out of 15 examined, this character is male-like, reaching to base of fifth to seventh ray. Posterior rays of second dorsal and anal reaching to base of caudal in females slightly beyond in males.

Ventral falling short of anus by about $\frac{1}{2}$ to $\frac{2}{3}$ of an eye diameter in both sexes.

A shoulder spot well marked; three conspicuous vertical dark bars on cheek; one on opercle not so marked; male having the interspinal membrane bordered with black, sometimes also in female. Other color marks not distinct in material examined. Originally described by Poey as having yellowish bars on body. Jordan and Evermann state that latter color mark is characteristic of male.

Mr. W. C. Schroeder informs me that the type is not now to be found in the Museum of Comparative Zoology. It, therefore, becomes necessary to adduce all available evidence in attempting to fix the status of this species. In his original description Poey gives six characters which may serve to differentiate the species; namely, (1) the caudal one-half as long as the body, (2) twelve dorsal rays, (3) thirteen anal rays, (4) the presence of a shoulder spot, (5) the presence of narrow, vertical, yellow bars on the body and (6) the presence of three dark bars on the cheek and one on the opercle. Later, Eigenmann who examined the type, added another salient character and that is the presence of a canine tooth in the lower jaw, in the outer row, posteriorly. This combination of characters is unlike any other species and unmistakably shows what species Poey had when he described his *stigmaticus*.

The canine tooth in the lower jaw may serve to distinguish this species at a glance from all the others by its large size after one becomes familiar with the relative size of the teeth in this genus. It is always present in both sexes. Sometimes one or two other large teeth are next to it, but these usually are markedly smaller, caninoid, of about the same size as in related species. The tooth is most prominent in specimens over 40 mm. in standard length. In the smaller individuals the size of the tooth is not so striking but is still appreciable on direct comparison. The position of the tooth is usually also of somewhat diagnostic value. It strongly inclines to the horizontal and projects more or less beyond the edge of the jaw. Consequently, it may be readily seen when viewed from the ventral side.

Of the other characters mentioned above, the material at hand proves the correctness of the length of the caudal and the number of fin rays as given in the original description. The specimens from Rio Janeiro also show clearly the presence of a shoulder spot and the bars on the cheek. These are not so marked but still faintly evident in the two specimens from Cuba. The body color is not shown by the available material, but Poey's description in that respect is corroborated by Jordan and Evermann, apparently based on specimens obtained by the former in Cuba.

The following material was examined: 1) Pensacola, Florida, U. S. N. M. 30218, one specimen in bad condition, but unmistakably this species. 2) Rio Janeiro, Brazil; Agassiz; M. C. Z. 4622, 22 specimens. As was pointed out by Eigenmann and Eigenmann, these specimens are very dark in color and the bars on the cheek are strongly marked and frequently edged with white. However, the material is in too bad condition to determine whether these color

differences have any taxonomic significance. In all essential details which could be determined, they agree with Poey's description and the following two specimens from Cuba. The above account is largely based on the Rio Janeiro material. 3) Cuba, M. C. Z. 13123, one specimen. 4) Cuba, Poey, M. C. Z. 13104. Two specimens in the bottle, the smaller one an example of the present species.

The species is, therefore, known at present from Pensacola, Florida, Cuba, and Rio Janeiro. In the literature, it is also frequently recorded from North Carolina. While, since the species occurs in Pensacola, it is quite possible that it extends its range as far as North Carolina, yet the records for the latter locality need verifications. Some of the records at least, such as that by Smith (Fishes of North Carolina, p. 365, 1907; material from Uncle Israel Shoal reexamined and found to be *boleosoma*), are evidently based on erroneous identification. There are no specimens in the National Museum from North Carolina. If present, it is certainly not common there, the common scaled goby at North Carolina evidently being *G. boleosoma*. There is also a published record of "*Gobius stigmaticus*" from Tisbury Great Pond, Martha's Vineyard, Mass. (Rep. Comm. Fish. Game Massachusetts, 1910, p. 150, 1911), but it is doubtful whether the single specimen recorded was actually an example of the present species. Since no description was published it is not possible to surmise the specific identity of this specimen.

This is apparently a medium sized species. The largest specimen examined, a female from Rio Janeiro, measures 55 mm. in standard length, 80 mm. including the caudal. It does not appear to be very common. It is certainly not as common as *boleosoma*. Since the type has been lost, the question may be raised as to why Poey happened to describe this species while failing to account for the comparatively abundant *boleosoma*. I may offer a plausible answer to this question. While collecting on the Gulf coast, *boleosoma* would sometimes come up in the seine in company with the goby which Poey called *Smaragdus costalesi* and I was struck by the superficial resemblance between the two. Indeed, sometimes they had to be closely examined to tell them apart. Poey, therefore, probably mistook *boleosoma*, if he came across any, as the young of his *costalesi*. The same mistake was previously made by Girard, as I have shown in another place. (Bull. U. S. Bur. Fish., vol. 47, p. 120, 1931.)

***Gobionellus manglicola*.**

Gobius manglicola Jordan and Starks, Pr. Cal. Ac. Sc. (ser. 2) 5: 495, 1895. (Mazatlan.)

Gobius manglicola Jordan and Evermann, Bull. U. S. Nat. Mus. no. 47, pt. 3, p. 2220, 1898.

Gobionellus sagittula Hildebrand (in part), Bull. U. S. Bur. Fish., 41: 287, 1925. (Triunfo, Salvador.)

Gobionellus manglicola Meek and Hildebrand, Publ. Field Mus. Nat. Hist. (Chicago) (Zool. ser.) 15: 883, 1928. (Panama.)

D. 6-12. A. 13. Scales 31-34. Caudal in two males, 23 and 31 standard length, 45 and 43%, respectively; in a female 30 mm., 34%.

Mouth but slightly oblique; lower jaw but little included almost coterminous with upper jaw; maxillary about reaches to vertical through posterior margin of pupil in male, through middle of eye in female. Teeth of male: upper jaw with outer row having 6 much enlarged, caninoid, recurved teeth in middle, those on sides not much larger than inner band of small teeth; lower jaw with outer row also conspicuously enlarged, the enlarged teeth extending about midway to angle of mouth, the hindmost one of these being most conspicuous, caninoid, recurved sideways; the inner row with four teeth near symphysis a little enlarged but not as salient as those of outer row. Teeth of female: upper jaw nearly same as male, outer row not as much enlarged; lower jaw with one conspicuous caninoid tooth, recurved sideways on middle of side, other teeth



Figure 3. *Gobionellus manglicola*. Drawn from a male, 32 mm. in total length, showing all the external evidence of being mature, taken at Triunfo, Salvador. Compare with figure 6 and see how the body color of this adult male closely resembles that of an immature *G. sagittula*; so that if a specimen in which the fins are not spread out be taken in company with the latter species and examined with the naked eye, it may readily escape detection.

in band nearly alike, the outer row but slightly enlarged. Scales in 31 to 34 oblique rows, 8 in an oblique row from origin of anal to base of second dorsal; scales on sides well ciliated except those above a line joining upper angle of base of pectoral and posterior third of first dorsal; area over anterior half of pectoral covered with scales nearly to predorsal keel, but scales not crossing over on keel, at least not on surface of skin; chest naked; belly with more or less embedded scales. Dorsal spines somewhat filamentous reaching to base of third ray of second dorsal in male not quite reaching origin in female; posterior rays of second dorsal and anal just reach base of procumbent caudal rays in female, slightly past that in male. (For measurements see Table 8, p. 29.)

The two larger specimens are somewhat faded but the color pattern may fairly well be seen when kept under water. Five oblong blotches on midline, irregularly marbled with dark over and between these blotches and on head. Shoulder spot not well marked. A dark blotch on cheek behind angle of mouth.

Pectoral and both dorsals streaked with rows of spots, most distinct on pectoral. Caudal cross streaked; in male only on upper half and near base, in female on entire length, but anterior streaks not quite extending to lower edge. Ventrals with pale center and broad black margin in male, with black center and broad pale margin in female. Male with an oblong blotch on first dorsal at upper half of fifth spine, and one on upper edge of caudal near its base.

According to its fin ray count, this species is close to *shufeldti* and *claytonii*. In its size and general appearance it resembles the very common *boleosoma* from the Atlantic coast. The color pattern simulates closely that of young *sagittula*. There is a possibility that the present species is more common than records in the literature would indicate, and that it has been masquerading as young *sagittula* in reports. From *sagittula* as well as *microdon*, the only two other gobies of the same genus within its range, it may readily be distinguished by its much larger scales and less numerous fin rays.

The species has been based heretofore on 4 specimens, the type from Mazatlan, and three others from the Pacific coast of Panama collected and described by Meek and Hildebrand. The above account is based on two of the latter and one specimen from Triunfo, Salvador, recorded here for the first time.

***Gobionellus boleosoma*.**

Gobius boleosoma Jordan and Gilbert, Pr. U. S. Nat. Mus. 5: 295, 1882. (Pensacola, Florida.)

Gobius encaeomus Jordan and Gilbert, t. c., p. 611, 1883. (South Carolina.)

Gobius encaeomus Jordan and Gilbert, Bull. U. S. Nat. Mus. 16: 945, 1883. (South Carolina.)

Gobius boleosoma Jordan and Gilbert, t. c., p. 946.

Gobius encaeomus Jordan, Pr. U. S. Nat. Mus. 7: 141, 1884. (Key West.)

Gobius encaeomus Jenkins, John Hopkins Univ. Circ. 5: 11, 1885. (Beaufort, North Carolina.)

Gobionellus encaeomus Jordan, Pr. U. S. Nat. Mus. 9: 28, 1886. (Beaufort, North Carolina.)

Gobius boleosoma Jordan and Eigenmann, t. c., p. 495, 1886. (Pensacola and Key West, Florida.)

Gobius encaeomus Jordan and Eigenmann, t. c., p. 496. (Beaufort, North Carolina.)

Gobius boleosoma Evermann and Kendall (in part) Bull. U. S. Fish Comm. 12: 117 (1892) 1894 (Texas, reexamined).

Gobius boleosoma Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2221, pt. 3, 1898.

Gobius encaeomus Jordan and Evermann, t. c., p. 2223.

Ctenogobius stigmaticus Smith, Fish. N. Carolina, p. 365, fig. 167, 1907 (N. Carolina; specimens reexamined; except figure).

Rhinogobius shufeldti Jordan and Dickerson (not Jordan and Eigenmann) Pr.

U. S. Nat. Mus. 34: 21, 1908. (Rio Panuco, Mexico, material reexamined.)
Ctenogobius boleosoma Starks, Fish. Stanford Exp. Brazil, p. 68, 1913. (Brazil.)
Gobius boleosoma Nichols, Bull. Amer. Mus. Nat. Hist., New York, 34: 146, 1915.
(Porto Rico.)

Ctenogobius stigmaticus Kuntz, Bull. U. S. Bur. Fish., 34: 426-429, fig. 54-68,
1916. (Account of embryonic development at Beaufort, North Carolina.)

Gobionellus encaeomus Meek and Hildebrand, Publ. Field Mus., Chicago (Zool.
Ser.) 15: 884, pt. 3, 1928. (Panama.)

D. 6-(10) 11 (12). A. (11) 12 (13). Scales 29 to 33. Caudal of 10 rather
large males, 33 to 39 mm. in standard length, showing the typical caudal for
that sex, 39 to 47%, the mode probably falling near 41%. Frequently a com-
paratively large male is encountered in which the caudal, in length and color,
resembles that of the female; while, on the other hand, some quite small males
have the caudal typically that of fully grown males, the condition of the caudal
fin probably depending on the state of maturity of the individual. Caudal of
5 females, 30 to 39 mm., 33 to 35%.



Figure 4. *Gobionellus boleosoma*. Drawn from an adult male, 41 mm. total length, taken
in a 30 foot seine in Bay La Mer on the coast of Louisiana.

Mouth small, placed low, nearly horizontal; lower jaw more or less included.
Maxillary in males over 40 mm. generally reaches to a vertical through anterior
margin of pupil or middle of eye; in females of same size, to anterior margin
of eye or pupil. Upper jaw of both sexes with an outer row of conspicuously
enlarged and an inner band of much smaller teeth; in lower jaw of male the
inner row conspicuously enlarged, especially the teeth near the symphysis,
the outer row slightly enlarged a few about midway between symphysis and
angle of mouth larger than others; in lower jaw of female band of teeth sub-
equal. Scales in about 29 to 33 rows from base of pectoral to base of caudal.
Area in front of dorsal entirely naked on surface of skin, two or three embedded
scales may be present in larger specimen, becoming conspicuous on drying,
rarely on surface of skin; chest and midline of belly naked. Third spine of
first dorsal longest, reaching to base of third ray of second dorsal when laid back
in larger males, do not reach past origin of second dorsal in largest females.

Length of posterior rays of second dorsal and anal vary with age and sex, reach slightly beyond base of caudal when laid back in larger males, not quite reaching there in females.

Body typically has 5 rather diffuse longitudinally elongate spots on the mid-line, the first under the pectoral, the second immediately behind the tip of the pectoral, and the last at the base of the tail, the last four being about evenly spaced. The first spot is more diffuse and rather larger than the others and frequently obsolescent. The other four are nearly always present. The back over these spots is irregularly peppered with more or less reticulating groups of minute spots somewhat resembling the fresh water *Boleosoma nigrum*. The second, third and fourth spots have two diffuse diverging streaks ascend from either end to the back forming three V-shaped marks. This characteristic V-shaped pattern is usually present in specimens over 30 mm., but is frequently obsolescent especially in the smaller females. As a general rule it is markedly more distinct in males. In some cases two diverging lines run from the spots to the ventral outline forming a double V-shaped pattern. Another characteristic color mark is a dark spot directly behind the gill opening and over the base of the pectoral. This is present but more or less diffuse in most specimens, frequently very strongly marked and sometimes altogether absent. This characteristic spot is frequently quite indistinct in life, becoming more prominent in preserved specimens. Both dorsals and caudal streaked with rows of small spots. In older males the caudal becomes dusky, and sometimes with an asymmetrical color pattern, the lower lobe being nearly uniformly dusky while the upper half having rows of dark elongate spots. In life two longitudinal pink bands may sometimes be discerned on the caudal of older males, becoming whitish in preserved specimens. Anal in younger females whitish with a submarginal black streak, the dark pigment spreading proximad with increase in size when the white margin becomes prominent; more uniformly dusky in oldest females; in younger males the anal more evenly sprinkled with dark pigment dots, usually with a row of more or less prominent dark specks at the base, becoming nearly evenly dusky in largest males. Pectorals and ventrals with little pigment in most females, more or less dusky in larger males. A short, oblique, quite diffuse bar from eye to upper lip. In general, the male is more intensely pigmented, and the typical color pattern more marked, the ventrals and caudal at times being nearly black. Both sexes also become more intensely pigmented with increasing size.

Prominent sexual differences, besides the difference in structure of the anal papilla are as follows. The teeth in the lower jaw of the female are subequal, while in the male the outer and inner rows are somewhat enlarged. The snout in the male is rather stouter, more bulldog-like, and the maxillary somewhat longer. The middle dorsal spines and the posterior dorsal rays are conspicuously longer in grown males. These last two characters have been used in some published keys to separate species without stating that it varies with

sex, such keys being misleading. The caudal is conspicuously longer in the male, this being true of all the species of the genus. The color pattern is the same in both sexes, but in the male the pigment is more intensely developed.

The present species may be identified readily by the distinctive V-shaped marks in its color pattern. This is, however, not always well marked, especially in the young and in females, and ultimately fades in the preservative. The number of fin rays, 11 in dorsal, 12 in anal distinguish it from related species in over 90% of the specimens. Only *smaragdus* normally has the same number but this species may be readily distinguished by the characters given in the key.

This is the most common and widespread scaled goby within its range. Specimens examined range from North Carolina to Panama, intermediate localities being Key West, Port St. Joe and Pensacola, Florida; Isle Derniere to Bastian Bay, Louisiana; Galveston and Corpus Christi, Texas; Rio Panuco, Mexico; and Rio San Juan Cuba. It has also been recorded from Brazil.

In about two hours seining in Bay La Mer, near Grand Isle, La., on the morning of July 28, 1930, there were obtained 179 males 21 to 46, and 289 females 22 to 40 mm. long. This body of water is quite shallow and with a muddy bottom and seems to be a favorite habitat of the species. The disproportion in the numbers of individuals of the two sexes is interesting. It can not be explained as the selective action of the gear for the same drag net was used throughout and if anything it acted more selectively on the females, since they are smaller on the average. The species is quite small. Over 650 specimens were examined altogether and only eight of these were over 50 mm. The largest were two females from Beaufort, North Carolina, measuring 58 and 62 mm., collected in August. In collections taken at the same time the males generally average larger than the females.

Common as this goby is, it is symptomatic of our present knowledge of the fishes of the Gulf of Mexico, to note that its status in the literature is quite uncertain. The nomenclature and synonymy finally adopted by me are based on a study of the types as follows.

Cotypes of *Gobius boleosoma*. U. S. N. M. 30860. Pensacola, Florida. Jordan and Stearns. The specimens are contained in two jars both bearing the same number. In one jar there are 13 males 29 to 47 mm. and 26 females 32 to 42 mm. and also one specimen of *Gobiosoma* 35 mm. long. The other jar contains two males 38 and 51 mm. The colors are largely faded, but in some of the males the characteristic V marks are evident, while the shoulder spot is quite distinct in many. The fin rays in these specimens are as follows (these counts have also been included in table 1).

	<i>Second dorsal</i>			<i>Anal</i>		
Number of rays	10	11	12	11	12	13
Number of specimens	2	35	2	2	36	1

There is no doubt but that these specimens represent the species here described. The statement in the original description, "Scales . . . on nape . . . not much reduced in size," is evidently an error, since the cotypes are scaleless on the nape and this is true of the species in general.

Type of *Gobius encaeomus*. U. S. N. M. 29673. Charleston, S. C.; C. H. Gilbert. A single specimen, male, with the caudal fin broken, standard length 32.5. The shoulder spot is still distinct but the rest of the pigment has largely faded. Second dorsal 11, anal 12. The snout is somewhat stouter than is

TABLE 5.—Measurements of *Gobionellus boleosoma*, expressed as percentages of the standard length.

	(3) ♀	(3) ♀	(3) ♀	(1) ♀	(4) ♀	(5) ♀	(3) ♂	(3) ♂	(3) ♂	(2) ♂	(1) ♂	(4) ♂
Standard	21.1	24.2	29.3	31.1	40	45.8	21.3	23.7	28.3	32.5	37.4	38.7
Caudal (6)	—	35.5	—	—	(34.7)	35.6	(32.4)	(32.5)	39.2	—	38.8	40.8
Depth	18.5	21.1	22.9	19.3	22.5	20.3	17.8	21.1	19.1	16.9	19.8	22.2
Peduncle	10.4	10.7	10.2	10.3	10.3	10.5	10.3	10.1	10.2	10.2	10.2	10.3
Head	26.5	26.5	26.3	26.0	25.5	26.0	27.2	26.6	26.1	26.2	27.6	25.1
Eye	10.0	10.7	8.5	8.0	7.5	8.1	8.5	8.4	7.4	7.7	7.5	8.5
Interorbital	—	2.1	2.0	1.6	2.0	1.6	1.9	1.7	1.8	1.5	1.3	1.6
Snout	8.1	8.7	9.9	8.0	9.3	9.6	8.9	8.4	8.1	8.0	9.1	11.6
Maxillary	10.0	11.6	10.2	10.3	10.0	10.9	9.4	11.0	11.0	12.6	11.2	13.4
Postorbital	15.2	15.3	16.0	14.8	14.0	14.0	15.0	16.0	14.8	15.4	14.7	15.2
Antedorsal	33.2	33.9	35.5	35.0	33.8	35.2	34.7	34.6	33.6	32.6	32.1	34.1
Ventral	27.5	26.0	24.9	25.1	22.5	25.1	24.9	25.7	26.1	27.4	25.9	25.6
Ventral to anal	28.9	29.3	30.7	29.9	28.8	30.3	28.6	29.5	29.0	28.3	28.1	26.9
Pectoral	23.7	24.8	22.2	21.5	22.8	20.0	23	25.7	24.4	—	—	27.4
Longest 2 D ray	13.7	14.5	15.4	14.1	15.8	17.2	15.1	16.8	19.4	16.9	20.6	24.5

(1) Cotypes of *Gobius boleosoma*, Pensacola, Fla. (2) Type of *Gobius encaeomus*, Charleston, South Carolina. (3) Louisiana. (4) Texas. (5) North Carolina. (6) The figures in parentheses represent specimens in which the caudal is slightly frayed at the tip but apparently nearly entire.

TABLE 6.—Correlation between the number of rays in the second dorsal and anal of *G. boleosoma*. Note that the dorsal has at least one ray less in all except six specimens.

Anal rays	Dorsal rays		
	10	11	12
11	1	2	
12	2	68	4
13		2	2

TABLE 7.—Correlation between the number of rays in the second dorsal and anal of both *G. boleosoma* and *G. shufeldti*. The numbers in parenthesis represent individuals which may be said to overlap. Note that there are only four such individuals in over 100 specimens enumerated.

Anal rays	Dorsal rays			
	10	11	12	13
11	1	2		
12	2	68 (1)	4 (1)	
13		2	(2)17	4
14			1	

usual in males of that size and the maxillary somewhat longer, reaching to posterior margin of pupil. These are the only differences noted. That this species occurs at North Carolina is shown by an examination of seven other specimens which are typical of the species. The slight deviation from the normal in the type of *encoecomus*, therefore, may be well ascribed to individual variation.

Attention may be called here to some material examined which can not be placed with certainty, as follows. 1) St. Thomas, Virgin Ids., St. Magens Bay; July 4, 1915; C. R. Shoemaker; U. S. N. M. 78150, one specimen, standard length 37 mm. 2) Cuba, near Nipe Bay; "Peter's Coll," M. C. Z., 10 specimens, 26 to 47 mm. standard length. 3) Cuba, Poey, M. C. Z. 13104, two specimens in the bottle, the smaller one is a *stigmaticus*, the larger one 40 mm. in standard length is of a different species and resembles the first two lots. This material seems to belong to a species which is intermediate between *boleosoma* and *smaragdus*. The fin rays are D 11, A 12 like in these two species. The teeth appear somewhat larger than in *boleosoma* approaching that of *smaragdus*. The caudal and the spines of the first dorsal are also somewhat longer than average specimens of *boleosoma*. The mucous papillae on the head are not as strongly marked as in *boleosoma*. In all of these characters, they diverge somewhat from *boleosoma* and approach *smaragdus*. However, unlike the latter species they have no scales in front of the dorsal. All the specimens are in poor condition. A study of this material suggests three possibilities. 1) The fish are specimens of *boleosoma*, the apparent differences being due largely to their poor state of preservation. This explanation appeals to me to be the most acceptable. 2) They may be small *smaragdus*. However, considering that some of the specimens are fully mature, while *smaragdus* is a rather large species, it seems unlikely. Also, the entire absence of scales on the midback, in front of the dorsal, shows that the possibility of their being young *smaragdus* is unacceptable, since they are large enough to have developed scales, if they belong to a species normally having scales in that region. 3) They may represent

an undescribed species. While, I am inclined to accept the first explanation, this latter supposition is not unreasonable. However, the material is not in good enough condition and in view of the uncertainties, as pointed out, it is not advisable to describe the fish as a new species at present.

TABLE 8.—Measurements of *G. manglicola* and *G. smaragdus* expressed as percentages of the standard length.

Part measured	Species						
	<i>G. manglicola</i>			<i>G. smaragdus</i>			
	(1) ♀	(2) ♂	(1) ♂	(3) ♀	(3) ♂	(3) ♂	(4) ♂
Standard length	30.1	22.5	30.7	65.0	59.2	66.3	76.3
Caudal	33.7	44.9	42.7			(71.0)	
Depth	19.3	18.2	19.2	19.8	19.8	19.9	17.3
Peduncle	10.6	10.2	10.8	10.2	9.5	10.6	8.7
Head	26.2	27.1	24.8	28.1	26.9	28.1	26.2
Eye	8.0	8.9	7.5	7.2	6.9	6.5	5.5
Interorbital	1.7	1.3	2.0	2.1	2.0	2.0	2.4
Snout	7.6	8.5	7.8	9.2	9.3	10.9	10.2
Maxillary	11.0	12.0	11.4	13.5	13.0	14.6	13.4
Postorbital	15.6	16.0	15.6	15.1	16.2	16.0	15.5
Antedorsal	34.9	34.7	31.6	36.9	35.5	34.5	35.1
Ventral	23.9	26.2	26.7	24.2	24.5	27.4	21.0
Ventral to anal	32.6	27.1	29.0	32.3	28.7	30.2	28.4
Pectoral	21.6	25.8		26.2	27.0	28.8	26.2

(1) Panama. (2) Salvador. (3) Cuba. (4) St. Augustine, Florida.

Gobionellus smaragdus.

Gobius smaragdus Cuvier and Valenciennes, Hist. Nat. Poiss. 12: 120 [Quarto ed. p. 91], 1837. (Cuba.)

Smaragdus valenciennesi Poey, Memorias Hist. Nat. Cuba 2: 280 (1856-58) 1861. (Cuba.)

Gobius smaragdus Poey, Rep. Fis. Nat. Cuba 1: 335, 1866.

Gobionellus smaragdus Poey, Rep. Fis. Nat. Cuba 2: 394 (Synopsis), 1868. (Cuba.)

Gobionellus smaragdus Poey, An. Soc. Esp. Hist. Nat. 5: 168 (Enumeratio, p. 126), 1876.

Gobionellus smaragdus Hay, Pr. U. S. Nat. Mus. 8: 552, 1885. (St. Augustine, Florida.)

Gobius smaragdus Jordan, Pr. U. S. Nat. Mus. 9: 49, 1886. (Havana, Cuba.)

Gobius smaragdus Jordan and Eigenmann, t. c., p. 497. (Havana; St. Augustine, Florida.)

Gobius smaragdus Eigenmann and Eigenmann, Pr. Cal. Ac. Sc. (ser. 2) 1: 64, 1888. (Rio Janeiro.)

Gobius smaragdus Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2227, pt. 3, 1898. (Marco Island, Florida; Charleston, South Carolina.)

D. 6-11. A. 12. Scales 39 to 46. Caudal of a male 113.5 mm. in standard length, 71% of body (part left, slightly broken at tip).

Snout appreciably broad and stubby; head markedly broad and tumid; mouth medium, somewhat oblique, lower jaw slightly included; maxillary about reaching to vertical through posterior margin of eye in both sexes; tongue thick, with a broad shallow emargination. Teeth of male; outer row of upper jaw very strongly enlarged, caninoid, recurved, enlarged teeth extending nearly to angle of mouth growing smaller posteriorly; inner band of small teeth conspicuously larger than in other species of genus; lower jaw with the inner row strongly enlarged, outer row slightly enlarged, a few teeth on side of outer



Figure 5. *Gobionellus smaragdus*. Drawn from a male, 76 mm. in standard length, taken at St. Augustine, Florida. The caudal in this specimen is broken off at the end and the figure does not represent the entire length of the fin. The color is rather faded, the figure showing the characteristic brown "rings," but probably not the entire color pattern.

row slightly larger than others. Teeth of female about the same, the enlarged teeth not as conspicuous as in male. Scales in about 39 to 46 rows from base of pectoral to base of caudal, 12 to 14 scales in an oblique row from origin of anal to base of second dorsal. Scales on sides ciliated to a level through about middle of first dorsal base, the ciliated scales extending on midline a little farther forward. Back in front of dorsal with reduced cycloid scales, scales extending forward in a somewhat wedge shaped patch nearly to a vertical through middle of opercle, this area being naked on sides of nape to base of pectoral; head naked. Third spine of first dorsal moderately and about equally filamentous in both sexes, in the three males reaches to about fourth to sixth ray of second dorsal, to base of third ray in the single female at hand. Posterior rays of second dorsal and anal reaching to base of caudal in female, but slightly past that in males. Transverse rows of papillae under eye not evident or faintly indicated in the unprepared specimens.

Specimens at hand more or less faded. Blotches on side not very marked,

probably faded. Shoulder spot present, distinct. A spot at lower angle of preopercle. Brownish rings present on side of head in males and also in female, the latter otherwise entirely faded. When examined closely with a lens the superficial appearance of rings may be seen to be due to blotches having their centers almost devoid of pigment specks. In one male rings also present on base of pectoral and on anterior part of body. Pectoral and dorsals barred with rows of spots. Caudal, anal and ventral blackish in one male. In the smallest male the caudal is barred.

This species may well be recognized by its tumid head, large teeth, and distinctive brown rings on the side of the head and anterior part of body. The body is markedly elongate. The caudal fin is unusually prolonged, probably longer than in any other species, but this is hard to determine absolutely since the fin is usually more or less broken in the long tailed species. The present species forms a connecting link between the preceding and following species. The caudal is very long while the scales on the body are intermediate in size.

Four specimens have been examined and measured, one from St. Augustine, Florida, and three from Cuba. It has also been reported from Charleston, South Carolina; Marco Island, Florida; and Rio Janeiro, Brazil.

Gobionellus sagittula.

Euctenogobius sagittula Gunther, Pr. Zool. Sc. London, p. 372, 1861. (West coast of Central America.)

Euctenogobius sagittula Gunther, Cat. Fish. Brit. Mus. 3: 555, 1861. (Western coast of Central America.)

Euctenogobius sagittula Gunther, Ann. Mag. Nat. Hist. (ser. 3) 9: 328, 1862. (West coast of Central America.)

Euctenogobius sagittula Gunther, Trans. Zool. Soc. Lond. 6: 389, 1868. (Panama.)

Gobius sagittula Jordan and Gilbert, Pr. U. S. Nat. Mus. 5: 380, 1882. (San Jose, Lower California.)

Gobius sagittula Jordan and Gilbert, Bull. U. S. Fish Comm. 2: 108, 1882. (Mazatlan, Mexico.)

Gobius sagittula Jordan and Gilbert, t. c., p. 111. (Panama.)

Gobius sagittula Jordan and Eigenmann, Pr. U. S. Nat. Mus. 9: 497, 1886.

Gobius longicaudus Jenkins and Evermann, Pr. U. S. Nat. Mus. 11: 146, 1888. (Guaymas, Gulf of California.)

Gobius sagittula Jordan, Pr. Cal. Ac. Sc. (ser. 2) 5: 494, 1895. (Mazatlan.)

Gobius sagittula Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2228, pt. 3, 1898.

Euctenogobius sagittula Boulenger, Boll. Mus. Zool. Anat. Univ. Torino. vol. 14, No. 346, p. 3, 1899. (Panama.)

Gobionellus sagittula Gilbert and Starks, Mem. Cal. Ac. Sc. 4: 171, 1904. (Panama.)

Gobionellus sagittula Starks, Pr. U. S. Nat. Mus. 30: 799, 1906. (Guayaquil, Ecuador.)

Gobionellus sagittula Starks and Morris, Univ. California Publ. Zool. 3: 224, 1907. (San Diego Bay, California.)

Gobius sagittula Osburn and Nichols, Bull. Amer. Mus. Nat. Hist. New York, 35: 175, 1916. (Augua Verde Bay, Lower California.)

Gobionellus sagittula Hildebrand, Bull. U. S. Bur. Fish. 41: 287, 1925. (Salvador.)

Gobionellus sagittula Meek and Hildebrand, Publ. Field Mus. Nat. Hist. Chicago (Zool. ser.) 15: 879, 1928. (Panama.)

D. 6-13. A. 14. Scales 59-68. Caudal in two males 72 and 105 mm. in standard length, 56 and 57%, respectively, in a female 54 mm., 44%.

Gape but little oblique. Mouth subinferior, lower jaw distinctly included. Maxillary reaches to about posterior margin of pupil in larger specimens, subequal in both sexes. Teeth in large male; upper jaw with the outer row strongly enlarged, sometimes a second row of enlarged teeth near symphysis in largest specimens, inner band subequal, quite small; lower jaw with the outer



Figure 6. *Gobionellus sagittula*. Drawing of a young male, 35 mm. total length, from Triunfo, Salvador. The caudal in large males is more than half as long as the body.

row and a series of 6 to 8 teeth in middle of inner row enlarged, but not as much as those of upper jaw. Teeth in female approximately the same as in male except that enlarged teeth not so marked, especially those in lower jaw. In specimens 55 mm. or less in standard length, the outer teeth much less enlarged, approaching that of *microdon*, but difference in the two species appreciable on direct comparison. Scales in 59 to 68 rows from upper angle of base of pectoral to base of caudal, 15 to 17 in an oblique row from origin of anal to base of second dorsal, strongly ciliated on sides, except those situated over pectoral; front of dorsal densely covered with reduced cycloid scales approximately to the level of posterior margin of preopercle; similar scales on chest and belly more or less embedded. Spines of first dorsal not filamentous in either sex, not reaching past origin of second dorsal. Posterior rays of second dorsal and anal not markedly differing with sex, reaching or nearly reaching to procumbent rays of caudal. Rows of cutaneous papillae well marked. Horizontal row at angle of mouth somewhat raised. A short transverse row behind eye and back of that two longer longitudinal rows.

Median line of sides with a series of five rather diffuse spots, more or less longitudinally elongate and tending to coalesce, especially in smaller specimens. Irregularly speckled over and between the spots. Shoulder spot present, rather diffuse. A characteristic brown spot on upper lip some distance in front of posterior angle of gape. Both dorsals, caudal and pectoral streaked with rows of brown spots, disappearing on distal half of caudal in larger males. Ventrals nearly unpigmented. A horizontal streak on middle of cheek and one below eye curving anteriorly downward towards mouth, a spot on opercle not well marked.

TABLE 9.—Measurements of *G. sagittula* and *G. microdon*, expressed as percentages of the standard length.

Part measured	Species						
	<i>G. sagittula</i>				<i>G. microdon</i>		
	(2) ♀	(2) ♂	(3) ♂	(1) ♂	(4) ♀	(5) ♀	(4) ♀
Standard	54.3	44.6	71.7	104.9	39.3	40.2	41.3
Caudal	44.4	47.3	56.1	—	38.4	42.0	39.7
Depth	16.2	16.4	13.7	—	18.7	21.4	21.6
Peduncle	8.6	8.5	8.0	7.8	10.1	10.5	9.9
Head	25.8	25.3	23.6	21.1	25.2	25.4	24.2
Eye	7.6	7.6	6.7	5.0	8.1	7.7	7.5
Interorbital	1.5	1.4	1.1	1.1	2.0	1.7	1.9
Snout	9.2	10.8	7.6	7.3	8.3	8.5	7.3
Maxillary	10.7	11.0	9.2	8.6	10.8	11.2	11.1
Postorbital	14.3	13.9	12.4	12.2	12.9	14.2	13.3
Antedorsal	33.9	34.1	30.8	29.6	33.5	33.6	33.4
Ventral	21.7	20.0	19.1	18.1	24.9	24.4	22.3
Ventral to anal	31.5	27.1	27.6	27.9	30.1	30.6	27.6
Pectoral	18.4	17.9	19.7	16.9	—	24.1	—

(1) Cotype of *Gobius longicaudus*, Guaymas, Gulf of California.

(2) Triunfo, Salvador. (3) San Juan Lagoon, Gulf of California.

(4) Cotypes of *Gobius microdon*, San Juan Lagoon, near mouth of Ahome River.

(5) Rio Juan Dias, Panama.

A unique color mark which, however, is apt to fade in preservative, is a brownish spot on the upper lip, nearer to the angle of the mouth than the symphysis. Large specimen may readily be distinguished by the greatly elongate form of the body which is unlike any other species of goby within its range. Small individuals resemble the rather uncommon *microdon* in the form of the body, but they may readily be distinguished from the latter by the larger teeth, and the different colorations as stated in the key to the species.

The color of small specimens strongly resembles that of *manglicola*, but the present species has more numerous scales and fin rays, and the back in front of the dorsal is scaled.

This species of goby appears to be quite common on the Pacific coast, since nearly every extensive published list contains a record of *sagittula*. It has been recorded from San Diego Bay, California to Guayaquil, Ecuador. Specimens studied are from the mouth of the Rio Mulege, Conception Bay; Guaymas; and San Juan Lagoon, all in the Gulf of California; and from Triunfo, Salvador. It attains to a large size for a goby, the longest examined being 164 mm. in total length, 105 mm. to base of caudal, a male from the mouth of Rio Mulege, Gulf of California. Jordan and Evermann state that it reaches a length of 8 inches.

Common usage has been followed in applying Gunther's name, *sagittula*, to the present species. It may be pointed out, however, that Gunther's description may apply equally as well to the species which is called here *microdon*. While since the present species appear to be more common than *microdon* and it is consequently reasonable to assume that Gunther had this species, it is not altogether certain until the types of *sagittula* are directly compared. Moreover, considering the collections obtained by Meek and Hildebrand, *microdon* also, seems to be not uncommon at Panama. Should the type of *sagittula* prove to be conspecific with that later described by Gilbert as *microdon*, the present species will take the name of *longicaudus*, the types of which have been re-examined and partly form the basis of the above account.

Gobionellus microdon.

Gobius microdon Gilbert, Proc. U. S. Nat. Mus. 14: 554, 1891. (San Juan Lagoon, Gulf of California.)

Gobius microdon Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2227, pt. 3, 1898.

Gobionellus microdon Gilbert and Starks, Mem. Cal. Ac. Sc. 4: 171, pl. 28, fig. 51, 1904. (Miraflores, Panama.)

Gobionellus microdon Meek and Hildebrand, Publ. Field Mus. Nat. Hist. Chicago (Zool. ser) 15: 879, 1928. (Rio Juan Diaz, Panama.)

D 6-(12) 13. A 14. Scales 59 to 67. Caudal in two females 40 and 41 mm. in standard length, 42 and 40%, respectively.

Mouth slightly oblique, lower jaw rather thin, not included, coterminous with upper jaw. Maxillary extending to about posterior margin of pupil. Teeth conspicuously small, outer row of upper jaw somewhat enlarged, but less so than in any other species, those of lower jaw subequal. Scales in about 59 to 67 oblique rows from upper angle of base of pectoral to base of caudal; 15 to 16 in an oblique row from origin of anal to base of second dorsal. Scales on sides ciliated to the level of middle of dorsal, ciliated scales extending a little

more forward on midline; the more anterior scales cycloid. Scales in front of dorsal extend forward to a short distance behind the eyes, except the predorsal keel being naked, at least on the surface of the skin, for greater part of its length, posteriorly. Chest naked, belly with more or less embedded scales. Dorsal spines quite filamentous reaching to base of fourth to sixth rays of second dorsal in all specimens, relatively somewhat longer in the smaller ones at hand. Posterior rays of dorsal and anal just reach base of procumbent rays of caudal in the larger specimens, not quite that far in small ones. Skin bearing longitudinal row of pores above angle of mouth sometimes slightly raised in form of a ridge. A transverse row of papillae directly behind eyes but little interrupted on midline, and a number of short longitudinal rows behind.

Body with a row of 5 to 7 vertically elongate diffuse blotches, from anterior ones faint bands extend to back. No definite shoulder spot. A dark streak behind eye and one on opercle quite faint.

The foregoing account is based on the two cotypes from the San Juan Lagoon, near the mouth of Ahome River, Mexico, and six specimens, three of 48 to 60 mm. and the others 23 to 33.5 mm., from Rio Juan Dias, Panama. All, except possibly the three smallest are females, judging by the appearance of the anal papilla, unless that structure does not differentiate the sexes in this species, which seems unlikely. The sex of the smallest specimens can not be judged by the anal papilla. The figure and description published by Gilbert and Starks appears to be that of a female, also. Consequently, no grown males of this species are positively known at present. Some of the teeth of the male when discovered, most probably will be found considerably larger than in the female.

The present species is close to *sagittula*, differing in the scales on the back extending a little farther forward, the markedly filamentous condition of the dorsal spines, the color pattern, and the smaller teeth. The latter difference may not be so marked in males when like sizes are compared.

The species is known at present only from the two cotypes from the Gulf of California; two specimens from Miraflores, Panama, reported by Gilbert and Starks; and 10 from Rio Juan Dias, Panama, described by Dr. Hildebrand. The largest known individual is 113 mm.

Gobionellus oceanicus.

Gobius cauda longissima, acuminata, Gronovius, Zoophylocii Gronoviani, fasc. 1, p. 82, pl. 4, fig. 4, 1763. (Locality unknown; non-binomial.)

Gobius oceanicus Pallas, Spicilegia Zool., t. 1, fasc. 8, p. 4, 1770. (First binomial name based on Gronow's account.)

Gobius lanceolatus Bloch, Oekono. Naturg. Fisch. Deutschlands 2: 12, pl. 38, fig. 1, 1784. (Martinique.)

Gobius lanceolatus Gmelin, Syst. Nat., t. 1, pars 3, p. 1203, 1789.

Gobius lanceolatus Lacepede, Hist. Nat. Poiss., 2: 545, pl. 15, 1800. (Martinique.)

- Gobius lanceolatus* Bloch and Schneider, Syst. Ichthy., p. 69, 1801. (Antilles.)
- Gobius lanceolatus* Cuvier and Valenciennes, Nat. Hist. Poiss. 12: 114 [quarto ed. p. 86] 1837. (Cuba; Martinique.)
- Gobius bacalaus* Cuvier and Valenciennes, t. c., p. 119, [quarto ed. p. 90] 1837. (Brazil; Surinam; Cuba.)
- Gobius lanceolatus*, Schomburgk, Hist. Barbadoes, p. 672, 1848. (Barbadoes.)
- Gobius lanceolatus* Gunther, Cat. Fish. Brit. Mus. 3: 50, 1861. (British Guiana; Brazil.)
- Gobius lanceolatus* Poey, Rep. Fis. Nat. Cuba 1: 334, 1866.
- Gobius bacalaus* Poey, ib.
- Gobionellus lanceolatus* Poey, Rep. Fis. Nat. Cuba 2: 393 (Synopsis) 1868. (Cuba.)
- Gobionellus bacalaus* Poey, t. c., p. 394. (Cuba.)
- Gobionellus lanceolatus* Poey, An. Soc. Esp. Hist. Nat. 5: 168 (Enumeratio, p. 126) 1876. (Cuba.)
- Gobionellus bacalaus* Poey, ib.
- Gobionellus lanceolatus* Poey, An. Soc. Esp. Hist. Nat. 10: 338, 1881. (Fauna Puerto Riquena by Gundloch) (Porto Rico.)
- Gobionellus oceanicus* Jordan and Gilbert (in part), Bull. U. S. Nat. Mus. 16: 636, 1883.
- Gobius oceanicus* Jordan, Pr. U. S. Nat. Mus. 9: 49, 1886. (Havana, Cuba.)
- Gobius oceanicus* Jordan and Eigenmann, t. c., p. 497. (Havana.)
- Gobius oceanicus* Eigenmann and Eigenmann, Pr. Cal. Ac. Sc. (ser. 2) 1: 65, 1888. (Brazil.)
- Gobius hastatus* Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2229, pl. 326, fig. 788, 1898. (Key West; Colon. U. S. N. M. 35155 from Key West, representing the lot from which the figure was drawn, reëxamined. The specimen from Colon which was described, is also evidently of the present species. Neither the description nor the figure apply to specimens from the coast of Texas.)
- Gobius oceanicus* Jordan and Evermann (in part), t. c., pl. 329, figs. 789 and 789a (Key West; Porto Rico. The figures based on specimens from Key West and Porto Rico evidently relate to the present species; not the description which is based on a specimen from South Carolina.)
- Gobius bayamonensis* Evermann and Marsh, Rep. U. S. Comm. Fish., p. 355, 1899. (Porto Rico.)
- Gobius bayamonensis* Evermann and Marsh, Bull. U. S. Fish Comm., vol. 20, pt. 1, p. 296, fig. 90, 1900. (Porto Rico.)
- Gobius oceanicus* Evermann and Marsh, ib., fig. 91.
- Gobius oceanicus* Metzlaar, Rap. Kolonie Curacao, p. 138, 1919. (Curacao.)
- Gobionellus oceanicus* Meek and Hildebrand, Publ. Field Mus. Nat. Hist. Chicago (Zool. ser.) 15: 877, 1928. (Panama.)
- Gobius oceanicus* Beebe and Lee Van, Zoologica 10: 222, fig., 1928. (Haiti.)

D 6 (7)-14. A (14) 15. Scales 60 to 76. Caudal of a male 123 mm. in standard length, 59%, one male 55.5 mm. 44.5%; two females 92.5 and 116 mm., 43.5 and 45%, respectively.

Mouth rather oblique, lower jaw hardly included, sometimes slightly projecting. Maxillary reaching to vertical through posterior margin of eye in large males, through posterior margin of pupil in females. Teeth in male; outer row of upper jaw moderately enlarged, in lower jaw outer row but slightly and inner row, especially those at symphysis, quite conspicuously enlarged; in female the enlarged teeth considerably less pronounced. Scales in about 60 to 76 oblique rows from upper angle of base of pectoral to base of caudal, ciliated on sides to about level of origin of second dorsal, ciliated scales extending, more forward on middle of sides, antedorsal area entirely covered with reduced cycloid scales nearly but not quite to posterior margin of eye; scales on predorsal keel still further reduced; present on chest and belly but more or less embedded. A group of scales of variable extent on upper anterior angle of opercle. Some more or less embedded and non-imbricate scales also scattered on cheek. Spines of first dorsal equally filamentous in young of both sexes becoming less so with increased size, third spine about reaching to base of seventh to eleventh ray of second dorsal when laid back in specimens under 50 mm. standard length, to between fourth and eighth ray in specimens 50 to 100 mm.; to between origin and base of fourth ray in individuals over 125 mm. standard length. Tips of posterior rays of dorsal and anal reach to base of caudal or somewhat past that in both sexes. A study of the available material suggests that all fins, including the caudal, become relatively shorter in very large individuals, but the rate of relative decrease could not be determined with the available material. Rows of cutaneous papillae more prominent than in any other species here described. A transverse row behind the eyes and a few short longitudinal rows back of that. A few short irregular rows under pectoral, near its base.

Prominent color marks characterizing this species are: (1) an oval brown spot directly over the midline at the level of the middle of the pectoral and (2) two to four small brown spots on the front edge of the first dorsal spine near its base. This last color mark is especially valuable in that it persists for the most part in preserved specimens which have otherwise nearly completely faded. The oval spot is present in both sexes and is frequently edged with a light shade, especially in the young. These color marks, especially the first mentioned, tend to become faint in very large individuals. Small specimens have a median row of small spots on the body which are more or less confluent suggesting a lateral band, and a more or less prominent spot at the base of the tail. These usually disappear in specimens over 100 mm. in standard length, but this juvenile color mark frequently persist in larger individuals.

There has been some question as to how many species these comparatively large, extremely elongate, and long-tailed gobies of the western Atlantic rep-

resent, and a number of characters have been suggested by various authors for separating them. Judging by the limited amount of perfect material available, I find only one character which seems to be of sufficient importance to be used for this purpose, and that is the number of scales. There is a correlation between the number of scales and geographical distribution as may be seen from table 10. The northern specimens have a greater number of scales, the frequency distributions of this character apparently forming a distinct bimodal curve. It is to be expected that if a large series is examined for this character, the two forms will be found to overlap. However, I do not have sufficient material with complete scalation and of sufficiently large size to insure an approximately correct count, to determine the degree of overlapping, if any.

As to the practical use of this character, it may be stated that it is almost impossible to determine with a high degree of accuracy the number of scales along the side, because they are rather irregularly arranged on the anterior half of the body. Repeated counts made on the same fish by the same observer may yield different results. However, the differences usually fall within narrow limits if the same method of counting is used. The method used by me is to count the number of rows rather than the individual scales, beginning with the row directly over the base of the pectoral and ending at the base of the caudal, since this method yields the most uniform results. It should further be noted that the number frequently varies considerably on both sides of the same fish. In table 10 the figures represent averages of four counts, two on each side, wherever possible.

Besides the number of scales along the sides, some other characters have been used for separating species. These are discussed below in chronological order.

Cuvier and Valenciennes after describing *lanceolatus* (= *oceanicus*) have separated a second species, *bacalauis*, from Brazil and the West Indies, based on the greater curvature of the back and a spot at the base of the caudal. The former character depends on individual variation and the state of preservation while the latter is a character of the young which frequently persists in older specimens.

Poey followed the preceding authors in recognizing two species, *lanceolatus* and *bacalauis*. He gives some comparative measurements of two specimens of approximately equal size (Repertorio Fis. Nat. Cuba t. 2, pp. 393-394). The only noteworthy difference is in the length of the caudal which is a sex character. The other differences such as the comparative measurements of the depth, head, eye and snout are slight and may well be due to individual variation, or to the persistence of juvenile characters in an older individual.

Jordan and Gilbert (Pr. U. S. Nat. Mus. vol. 5, p. 613, 1883) suggested that there may be two species, but they did not actually separate them under two names. This suggestion was apparently based on two specimens, one of 11 inches from South Carolina and the other one from Colon, the size not being

stated. They suggest four characters for separating specifically the Colon specimen; namely, 1) a relatively longer head, 2) larger scales, 3) "obsolescence of the patch of scales on opercles," and 4) a different coloration. Of these four, the larger scales is the only character which may be used consistently for specific distinction (see Table 10). The relative difference in the length of the head varies markedly with age; while the development of the patch of scales on the opercle varies with the individual (see discussion below). The difference in coloration is also due to age as described above.

Jordan and Evermann using the same characters as suggested by Jordan and Gilbert divide these gobies into two species, but they reverse the application of these characters and ascribe the larger scales to *hastatus* which is the northern form. In reality the northern form has the smaller scales, as stated by Jordan and Gilbert and as shown in Table 10.

In regard to *Gobius bayamonensis* Evermann and Marsh, it is based on a specimen which falls near the extreme of a regular frequency distribution, as far as the number of scales is concerned, and its separation as a distinct species is, therefore, unjustifiable. According to my method of counting, I get a slightly smaller number than given in the original description. Four counts made on the type specimen, two on either side, gave numbers varying from 69 to 74. Of the other differences pointed out by the authors of this supposedly distinct species, the scaling of the opercle is due to individual variation; while the differences in the depth, maxillary and head are due to the large size of the type specimen. The figure of *bayamonensis* is incorrect. The two dorsals are separated as is normal for the species, not continuous as the figure purports to show.

The length of the head decreases relatively in a striking manner as the fish grows. This is true not only of this species, but also of the others in which the body is greatly elongate, as may be seen in the table of measurements of small and large *sagittula*. Of the available material of *oceanicus*, data obtained from measurements of the head are presented in Table 11. While the number of specimens measured is of course insufficient to work out the statistical curve for the species, yet it shows strikingly the relative decrease of the length of the head with age, or to state it in another way, as the fish grows, the length of the body increases at a greater rate than the head. It is evident, therefore, that this character can not be used for separating species when specimens differing widely in size are compared. Whether there is a specific difference when specimens of like size are compared, remains to be learned. However, if any specific difference is shown in the relative length of the head by an examination of a large series of specimens, the available material certainly shows that such specific difference, if any, will be much less than that due to age.

As to the extent of squamation of the opercle, I have examined and took detailed notes on twenty specimens of *oceanicus* and find a condition which may be summarized as follows. There is a variable patch of scales at the

upper anterior angle of the opercle. The scales are more or less irregularly arranged and it is not altogether possible to visualize them as occurring in definite rows. However, roughly it may be stated that there are usually 3 or 4 longitudinal rows, frequently 2 or sometimes 5. The number of scales in the rows usually diminish downward, the dominant numbers being 4 or 5 in the uppermost and 2 or 3 in the lowermost row. Sometimes the rows have the same number. The patch of scales usually extends half way across the opercle, sometimes nearly to its posterior margin. In one specimen I found only three scales altogether, in two rows. The variability of the squamation is such as to force the conclusion that if some system is adopted of enumerating either the rows or the total number of scales, this character will form an ordinary frequency distribution curve without definite breaks which may serve for separating species.

To sum up, of the characters which have been used hitherto in attempts at specific division of the common, large and long-tailed gobies of the western Atlantic, the numbers of scales along the sides appears to be the only one which has some taxonomic value. The other characters are due to age, sex, state of preservation and individual variability.

TABLE 12.—Measurements of *G. oceanicus* and *G. hastatus*, expressed as percentages of the standard length.

Part measured	Species								
	<i>G. oceanicus</i>						<i>G. hastatus</i>		
	(2) ♀	(3) ♀	(2) ♂	(2) ♂	(3) ♂	(1) ♂	(4) ♀	(4) ♂	(4) ♂
Sex									
Standard	36.0	92.5	36.1	55.5	123.00	147.0	144.3	124.0	148.6
Caudal	41.7	43.5	45.7	44.5	59.0	—	—	—	—
Depth	19.4	18.5	18.3	18.4	15.4	16.7	17.2	14.9	14.9
Peduncle	8.9	10.2	9.7	10.3	9.0	9.6	10.3	9.6	9.3
Head	25.3	21.8	25.5	23.1	20.2	19.2	18.8	18.5	18.4
Eye	6.9	5.9	7.2	6.6	4.5	4.2	3.5	3.9	3.4
Interorbital	1.4	1.5	1.1	1.6	1.3	1.3	1.8	1.5	1.7
Snout	8.3	6.8	7.8	7.7	6.8	5.9	7.1	6.6	7.2
Maxillary	11.4	9.7	11.1	10.6	11.0	11.1	9.2	9.8	10.3
Postorbital	14.2	12.0	15.2	12.8	11.5	10.8	10.7	10.1	10.1
Antedorsal	33.3	29.9	34.3	32.8	27.5	27.9	27.7	27.0	26.6
Ventral	25.0	22.3	24.4	27.0	19.5	20.7	18.4	18.7	17.8
Ventral to anal	34.2	33.2	31.3	33.7	28.0	28.9	31.1	27.6	30.3
Pectoral	—	—	—	24.5	—	21.1	17.1	19.5	17.2

(1) Type of *Gobius bayamonensis*; Porto Rico. (2) Panama. (3) Cuba. (4) Louisiana.

Specimens examined are from Key West, Florida, Cuba and the Atlantic coast of Panama. Reported also from Brazil and several localities in the West Indies.

Since two species are recognized, one a southern and the other a northern, the question may well be raised as to which one of the two, the name *oceanicus*, the earliest one applied to these gobies, belongs properly. Since no locality is indicated in the original description, it may be taken to apply to either species, and it remains to determine how later authors restricted that name. Bloch (1784) seems to be the earliest reviser to restrict the name *oceanicus*, including it in the synonymy of his *Gobius lanceolatus* which came from the West Indies. The name *oceanicus* must, therefore, be used for the southern species. This permits the use of the later name, *hastatus*, for the northern species.

Gobionellus hastatus.

Gobionellus hastatus Girard, Pr. Ac. Nat. Sc. Philadelphia, p. 168, 1858. (St. Joseph's Island, Texas.)

Gobionellus hastatus, Girard, U. S. and Mex. Bound. Survey, pt. 2, Ichthyology, p. 25, pl. 12, figs. 7-8. 1859. (St. Joseph's Island, Texas.)

Gobionellus oceanicus Jordan and Gilbert Pr. U. S. Nat. Mus. 5: 613, 1883. (South Carolina.)

Gobius oceanicus Jordan and Evermann, Bull. U. S. Nat. Mus. 47: 2230, pt. 3, 1898. (Description of specimen from South Carolina; not the figures which are based on specimen of true *oceanicus* from Key West and Porto Rico.)

D 6-14. A 15. Scales 76 to 89. Caudal in a female 106.5 in standard length 44.5% (caudal in all available males broken).

This species is very similar to *oceanicus* in its appearance, the relative proportion of the various parts and coloration. A study of Table 12 shows that the head is somewhat shorter, the eye smaller, the snout longer and the maxillary shorter in the few specimens measured. The differences are, however, small and whether they will hold when large series are measured is very problematical. The slight difference in the length of the head in specimens of similar size of the two species is much less than between large and small specimens of *oceanicus* (compare with Table 11). The scales, however, are more numerous. It is evidently a northern form having a larger number of scales than *oceanicus*. I do not have sufficient material with complete scalation to determine more closely the relation between the two forms, but the difference in the few specimens counted, as shown in Table 10 is sufficient to indicate that this character has a real value, although the two curves will no doubt be found to overlap when more material is examined. The degree of overlapping, both morphologically and geographically, remains to be determined. For a discussion of the method of counting the scales see under *oceanicus*. The number of vertebrae in two specimens, one from Pensacola and one from Porto Rico, was found to be the same, namely, 26.

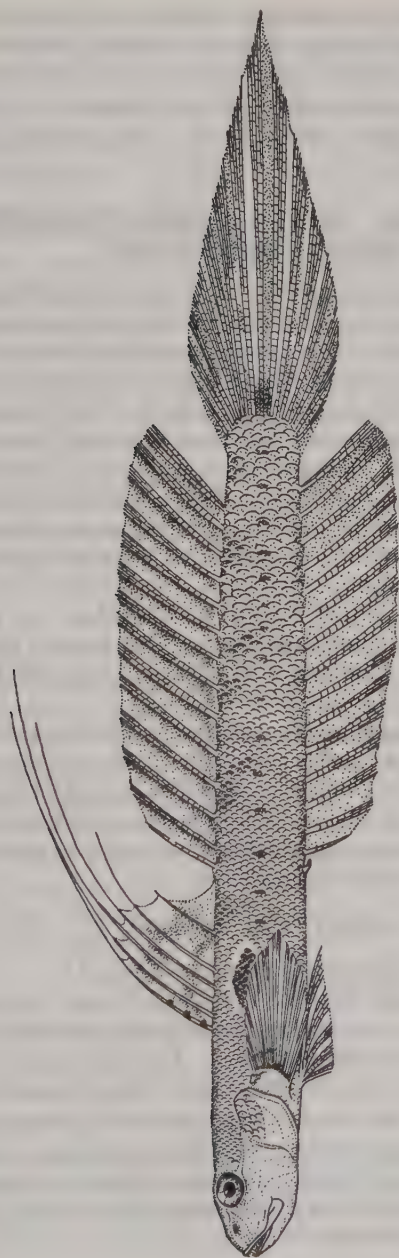


Figure 7. *Gobionellus hastatus*. Drawing of a male, 125 mm. standard length, taken at Pensacola, Florida, showing juvenile characters. The median row of spots completely disappears in large specimens. The oval spot at the pectoral and the small spots on front of the dorsal also tend to become faint with increasing size. The dorsal spines lose their extremely filamentous condition and the caudal becomes relatively shorter. The caudal in the specimen figured is broken at the tip and the illustration does not represent the true length.

No young of this species are available for study. Judging by two specimens from Pensacola, 106.5 and 125 mm. in standard length, it seems probable that the juvenile characters, namely, the long filamentous condition of the dorsal spines and the lateral row of confluent spots disappear at a larger size than specimens of *oceanicus* from further south. The northern form probably matures later in life.

THE RELATIONSHIP OF THE SPECIES COMPRISING THE GENUS GOBIONELLUS.

Besides the species described above, which were actually studied by me, this genus evidently also includes *stomatus* Stark, and probably also *luzonica* Seale and *fontanessi* Bleeker. For a discussion of the probable relationship of these three species see below. *Gobius eigenmanni* Garman (Bull. Lab. Nat. Hist. State Univ. Iowa, vol. 4, p. 88, pl. 3, fig. 1, 1896) possibly also belongs to the present genus, but it has been described as having 7 dorsal spines which makes its position doubtful. I am informed that the type of this species does not exist at present at either the Museum of Iowa State University, the Museum of Comparative Zoology or the U. S. National Museum. When rediscovered it may probably be recognized by its distinctive color marks, if the number of spines as stated in the original description is erroneous. The other species listed by Jordan and Evermann (Bull. U. S. Nat. Mus. No. 47, pt. 3, 1898) and in the new edition of the check list (Rept. U. S. Comm. Fish., 1928, pt. 2, 1930), under *Gobionellus*, *Rhinogobius* and *Gobius* apparently belong to other genera than the one treated in the present discussion.

Since the genus as treated here comprises species differing widely in characters which have been used by a number of authors to separate genera, such as the size of the scales, the squamation in front of the dorsal and on the side of the head, and the length of the caudal, it is desirable to divide it into subgenera in order to correlate the present report with the work of such authors and perhaps to show better the relationship of the species.

Gobiex, NEW SUBGENUS.

GENOTYPE: *Gobionellus stigmaturus* (Goode and Bean).¹

DEFINITION: Scales large, less than 35 oblique rows. Caudal moderately pointed in male, sometimes nearly rounded in female. Second dorsal and anal normally with 12 and 13 rays, respectively. Area in front of dorsal scaled to preopercle, the scales not much reduced. Side of head naked. Dorsal spines but little filamentous. Size small. Body moderately elongate. A median

¹ Since I have not examined the type of *Gobius stigmaturus* and there must consequently be some doubt as to whether I correctly referred my material, it is to be understood that the genotype of the present subgenus is to be that species which is called *stigmaturus* in the present report.

series of spots present. No well defined shoulder spot. The genotype is the only species known at present. It is a strongly marked species which may be readily identified.

Gobica, NEW SUBGENUS.

GENOTYPE: *Gobionellus boleosoma* (Jordan and Gilbert).

DEFINITION: Scales large. Caudal lanceolate, more or less elongate, especially in the male. Second dorsal and anal normally with 12 and 13 rays, respectively, except in *boleosoma* in which the normal numbers are 11 and 12, respectively. Midback in front of first dorsal without scales, except in *shufeldti* which has a few reduced scales on midback in front of dorsal, sometimes 2 or 3 embedded scales present in large specimens of other species also. Side of head naked. Anterior spines of first dorsal moderately or excessively filamentous in males, sometimes also in the females. Size rather small or medium. Body moderately elongate. A median series of rounded or horizontally elongate spots present. Shoulder spot present or absent. This subgenus includes *stigmaticus*, *claytonii*, *manglicola*, *boleosoma* and evidently also *shufeldti*. The latter species, by the presence of a few reduced scales in front of the dorsal forms a connecting link with the preceding subgenus. However, in its appearance and physiognomy it resembles more *G. claytonii*.

SUBGENUS *Smaragdus*.

Smaragdus Poey, Memorias Hist. Nat. Cuba, t. 2, p. 279, 1861.

GENOTYPE: *Gobionellus smaragdus* (C. and V.) = *Smaragdus valenciennesi* Poey, by absolute tautonymy.

DEFINITION: Head strikingly tumid. Teeth comparatively larger than in any of the other species. Scales medium, usually more than 40 oblique rows. Caudal excessively elongate, nearly 75% of body length in large males. Second dorsal and anal normally with 11 and 12 rays, respectively. Antedorsal area covered with reduced scales, to about level of middle of opercle. Side of head naked. Dorsal spines moderately elongate. Size medium, body becoming elongate with age. Shoulder spot well marked. The genotype is the only species known at present.

Gobatus, NEW SUBGENUS.

GENOTYPE: *Gobionellus microdon* (Gilbert).

DEFINITION: Scales small, in 58 to 69 oblique rows. Caudal strikingly elongate, about 50% or more of body length in grown males. Second dorsal and anal normally with 13 and 14 rays, respectively. Antedorsal area covered with small cycloid scales to a level through preopercle or more anterior to that. Side of head naked. Dorsal spines hardly or moderately filamentous depending on the species. Size medium to medium large; body becoming quite elongate with increase in size. A median series of spots present, tending to become

transversely elongate in one species. Shoulder spot present or absent. Besides *sagittula* and *microdon* which are described above, this subgenus apparently also includes *Gobionellus stomatus* Starks (Fish. Stanford Exped. Brazil, p. 67, pl. 10, 1913). The latter species has not been examined by me. It is apparently closest to *microdon*, as far as may be judged from the figure and description. It is said to have cycloid scales all over which is unlike any of the species examined by me.

SUBGENUS *Gobionellus*.

GENOTYPE: *Gobionellus oceanicus* (Pallas.) (see p. 4).

DEFINITION: Scales small to very small, in 60 to 89 oblique rows. Caudal very elongate, over 50% of body length in the larger males, tending to become shorter in very large individuals. Second dorsal and anal normally with 14 and 15 rays, respectively. Back in front of dorsal scaled to within a short distance behind eyes. Patch of scales of variable extent present on upper part of opercle; scales of about same size sometimes also present on cheek, embedded and non-imbricate. Dorsal spines excessively and about equally filamentous in the young of both sexes, becoming less so with age. Ventrals reaching about $\frac{3}{8}$ to $\frac{2}{3}$ of the distance from their origin to origin of anal in the larger individuals, reaching relatively further back in the young. Size large, body becoming strikingly elongate with age. A lateral band made up of a median series of more or less confluent small spots, disappearing with age. No shoulder spot. A spot on side under upper edge of pectoral.

This subgenus includes two species, *oceanicus* and *hastatus*, which are very similar in appearance, color and structure. They differ chiefly in the frequency distribution of the number of oblique rows of scales on the side, being separable by this character into one southern and one northern species. By those who prefer to use trinomials they would possibly be regarded as subspecies.

SUBGENUS *Biat*.

Biat Seale, Philippine Jr. Sc. (A.) 4: 532, 1909.

GENOTYPE: *Biat luzonica* Seale, by original designation.

DEFINITION: Scales very small, in 90 to 104 oblique rows. Caudal probably not much elongate. Second dorsal and anal normally with 16 and 17 rays, respectively. Antedorsal area scaled to about level of preopercle. Side of head naked. Dorsal spines but slightly filamentous. Ventrals about reaching anal opening. Size large, body markedly elongate in large specimens. Body with cross bars.

The known species of this subgenus seem to be *luzonica* Seale and *fontanesii* Bleeker. They have not been studied by me. For descriptions and as a guide to the literature see Herre (Gob. Philip. pp. 246 and 242, 1929). The two species are evidently congeneric. In their small scales, the number of fin rays, and their large size, they are quite close to *Gobionellus hastatus*. The chief

differences seem to be in the longer ventrals and the shorter caudal, approaching in these respects the species of the present genus standing at the beginning of the series. However, the true character of the caudal length remains to be proven. The caudal length varies considerably with sex in all the species examined by me, and in addition, as a practical difficulty, it is frequently broken off at the tip. Since the two species of this subgenus are at present known from but a few recorded specimens, it is quite possible that the caudal will prove longer than at present described, especially in males having the caudal unquestionably not broken at the tip. In this connection it may be interesting to note that I have examined some large specimens of *hastatus* and *oceanicus* in which the caudal, offhand, might have been described as short and rounded. In some of these the caudal rays may be plainly seen to be broken off when examined with a binocular. Moreover, in the latter two species the caudal evidently becomes relatively shorter in very large specimens.

Synopsis of the Subgenera.

- A. Scales large or medium, in about 29 to 44 oblique rows. Second dorsal normally with 11 or 12 rays. Anal normally with 12 or 13 rays. Side of head scaleless.
- B. Caudal not excessively elongate not much more than $\frac{1}{2}$ as long as body in males, usually less than $\frac{1}{2}$ the body length.
- C. Back in front of dorsal covered with moderately reduced scales. *Gobiex.*
- CC. Back in front of dorsal without scales. A few reduced scales present in *shufeldti*.....*Gobica.*
- BB. Caudal excessively elongate nearly $\frac{3}{4}$ as long as body in large males. Second dorsal and anal normally with 11 and 12 rays, respectively. Back in front of dorsal covered with scales for some distance. *Smaragdus.*
- AA. Scales small, in about 59 to 89 oblique rows.
 - D. Second dorsal and anal normally with 13 and 14 rays respectively. Side of head naked. Caudal very elongate.....*Gobatus.*
 - DD. Second dorsal and anal normally with a greater number of rays.
 - E. Side of head naked. Second dorsal and anal normally with 16 and 17 rays, respectively. Caudal not much elongate. Tip of ventrals nearly reaching vent. Body with cross bars.....*Biat.*
 - EE. A patch of scales present on opercle, and some also on cheek. Second dorsal and anal normally with 14 and 15 rays, respectively. Caudal very elongate. Tip of ventral ending a considerable distance in front of vent in large individuals. No cross bars. *Gobionellus.*

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A GEOGRAPHIC-ECOLOGICAL ANALYSIS OF THE SEASONAL CHANGES IN TEMPERATURE CONDITIONS IN SHALLOW WATER ALONG THE ATLANTIC COAST OF THE UNITED STATES

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INTRODUCTION

Although the literature may be found to contain many accounts of temperatures observed in separate and restricted areas of the shallow-

water zone along the Atlantic Coast of the United States, it would appear that a comprehensive treatment of temperature conditions in this entire coastal region has previously only been attempted once, by Rathbun (1887), whose valuable records form a very important part of the material for the present investigation, and whom we shall therefore have frequent occasion to refer to the following. In Rathbun's work, the temperature observations are first presented in the conventional manner in annual curves for each separate locality, but an attempt has also been made to show them in their geographical relationship in six graphs in which both time and location are given consideration. The location is only expressed in terms of geographical sequence, however, and not in terms of actual geographical distances, all points of observation being separated by equal interspaces in the graphs, although, for instance, Martin's Industry Lightship is about 17 times as far from Fowey Rocks as the latter point of observation is from Carysfort Reef. Rathbun's method of presentation consequently fails to give a true picture of the actual geographical temperature gradient and its changes during the seasons, and his graphs, although they are of a related character, thus differ fundamentally from those developed for the purposes of the present report.

For this and other reasons of a similar nature many biologically highly important features of the annual temperature cycle in the shallow-water belt here considered, such as for instance the establishment of seasonal temperature barriers at Cape Cod and at Cape Hatteras, the development of eurythermal and stenothermal conditions in these two barrier regions at opposite times of the year, and so on, remain obscure or entirely undisclosed in Rathbun's temperature charts and are not brought out in his text. Nor have these various features received any clear elucidation in the subsequent literature, which has strangely failed to carry on with the problem in spite of its great importance particularly where the biology of migratory forms such as most of the commercial species of fish are concerned, as already very well stated by Rathbun.

This peculiar neglect of such an important field of information for marine biological investigations has undoubtedly in a considerable measure been due to a prevailing feeling that it would not be worth while to attempt to carry the work any further until our knowledge and understanding of the oceanographic conditions along the western margin of the North Atlantic Ocean had progressed to a point where

it would be possible to fit the coastal shallow-water temperatures into a total picture of hydrographic causes, effects and relationships. However justified this attitude may seem from the point of view of the physical oceanographer, it can have no merits in the eyes of the marine biologist who is directly concerned only with the actual facts of environmental conditions in the sea, and is only indirectly and very remotely interested in the hydrographic explanations of these facts.¹ While the physical oceanographers continue their search for the explanation of the various factors influencing temperatures and other features of the sea, the biologists are therefore in need of a presentation of the actual facts of oceanography, which will permit them to correlate biological processes with the environmental conditions under which they occur and with the fluctuations in these conditions in point of space and time.

In the present article, the author shall therefore attempt to present the facts of the temperature conditions in shallow water along the Atlantic Coast of the United States in a manner which might be suitable for the special requirements of the biologist, without any pretensions at all in regard to the hydrographic interpretation of the facts thus presented. In many instances the probable cause of the temperature conditions, as actually observed, is more or less obviously indicated in the data themselves and will be mentioned accordingly in the text. In other cases theoretical possibilities suggesting themselves to the writer may be briefly alluded to as such. But so far as hydrographic explanations are concerned anything suggested in this article should rather be considered in the nature of questions directed at the physical oceanographers working with the problems of this region, than as definite theories advanced by the writer. When certain general laws pertaining to the temperature conditions in various sections of the coastal waters here considered seem to be revealed by the analysis of the records given on the following pages, this, of course, merely constitutes a disclosure of facts but not a discovery of their causes.

¹ In problems in which the mechanical transportation of biological communities, nutritive substances, and so forth, by ocean currents play any part at all these currents themselves naturally are among the oceanographic facts with which the biologist must concern himself, but the statement still holds good that he has no more direct interest in the hydrographic explanations and interpretations of the facts of the ocean currents than he has in the ultimate cosmic causes of the temperature conditions he observes in the environment in which his investigations take place.

ACKNOWLEDGMENTS

The author wishes to express his indebtedness to the United States Bureau of Fisheries for placing at his disposal the temperature records on which the following considerations are largely based, and to Dr. Henry B. Bigelow, of Harvard University and the Woods Hole Oceanographic Institution, for additional information and valuable advice received in the preparation of this report.

MATERIAL

The material upon which the present account is based consists in part of the temperature curves and isothermal graphs published by Rathbun (1887) in part of the surface temperature records kept in more recent years, at the request of the Bureau of Fisheries, by the officers and keepers of nineteen selected lightships and lighthouses along the Atlantic coast of the United States from Dry Tortugas to Maine.

In the records for recent years, of which only 1928, 1929 and 1930 are here considered, the temperatures have as a rule been entered twice daily, at 8 A. M. and at 6. P. M. About 40,000 single observations are thus available for the three-year period.

Rathbun's data, also consisting of surface-temperatures only, were collected in a similar manner during the years 1881-85 from 24 lightships and lighthouses extending in a series all the way from Maine to Dry Tortugas. In the original records the time of observation was adjusted to the stage of the tide, temperatures being taken at first high water and at first low water after 7 A. M. The original records and tables are not published in Rathbun's report, however, and for the purposes of the present account we are therefore confined to the use of his temperature charts, based upon ten-day averages, which will be perfectly adequate for most of our needs. By a consideration of five-day or ten-day averages only, it will certainly be quite immaterial whether the semi-daily single observations have been made at certain hours or at certain stages of the tide.

The positions of the various lighthouses and lightships are shown in figure 1 on page 6 and are further accounted for in detail by Rathbun (1887)² in so far as their temperature records were included in his data. In the material from recent years, we also have available

² *Loc. cit.* pp. 162-164 and in the explanations of temperature charts 2-25.

several series of observations from lightships which have been added since Rathbun's time, and from some of the older lightships which have altered their positions during the intervening years. These additions and alterations are all accounted for in the brief review, below and on the following pages, of all points of observation from which records were obtained either by Dr. Rathbun during the period 1881-85 or by the Bureau of Fisheries in recent years. Where no changes have occurred or no recent observations have been made, these short descriptions of each location will be largely straight quotations from Rathbun's account.

In the discussion of his data Rathbun (1887, p. 161) expresses the opinion that his records from the stations north of Cape Hatteras (except Vineyard Sound and Nantucket Lightships) gave frequent indications of careless observation during exceedingly cold weather in the months of January and February, the thermometer, at times, not being read quickly enough after it had been withdrawn from the water. The data from the northern stations for these two months have therefore been omitted from Rathbun's temperature charts. No internal evidence of similar inaccuracies or systematic errors of significant magnitude is to be found in any of the the winter temperature records from recent years. The reported temperatures of the surface water, on the contrary, show a great consistency with each other under the most changeable conditions with regard to the temperature of the air, and there is hardly a single instance of an obviously improbable observation being entered in the records for the winter months, even as an error of writing. For these reasons the writer feels confident that the temperature data for the months of January and February during the years 1928-30 are also north of Cape Hatteras fully comparable with the records from the other seasons of the year, and can be considered on that basis without any reservations.³

ACCOUNT OF LIGHTHOUSE AND LIGHTSHIP LOCATIONS

The distances between stations given in the following account are coastwise distances, measured along the shallow water zone (see page 24).

³ The thermometers used during recent years are protected by a wide metal tube open on *one* side and at *one* end only, so that a considerable volume of water is retained around the mercury bulb, and the possible effect of wind and air-temperature within a reasonably short time of exposure is greatly reduced.

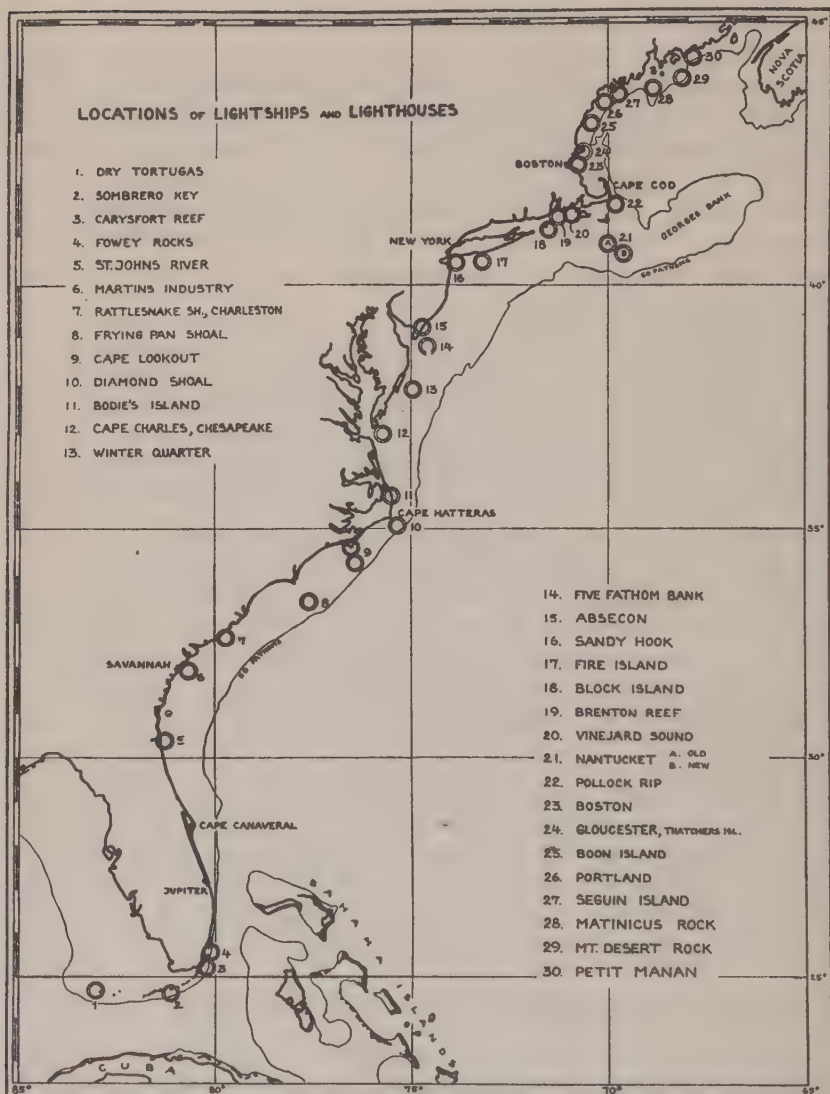


Fig. 1.—Chart showing locations of lightships and lighthouses. Small circle and dot between stations 5 and 6 indicate location of Brunswick Lightship, abandoned in January 1929.

Dry Tortugas lighthouse.—Located on the western island of the Tortugas, at the southwestern extremity of the Florida Reefs. The light-house is situated on the eastern side of Loggerhead Key (or island), which is bordered by a channel having depths of 10 to 12 fathoms

and occupied by strong tidal currents. The surface temperature observations were taken where the water is only 5 feet deep, and show indications of local influences, which render them more or less unsatisfactory with respect to the open waters surrounding the reefs (Rathbun). 24° 38' N. 82° 55' W.

Sombrero Key lighthouse.—In about 4 feet of water on the outer line of the reefs. About 3½ miles from the nearest key, 5½ miles from the 100 fathom contour and immediately adjacent to depths of 10 fathoms or more on the outside. About 63 miles from Carysfort Reef and 100 miles from Dry Tortugas. 24° 38' N. 81° 31' W. Records from this station have only been obtained during recent years.

Carysfort Reef lighthouse.—Located near the northeastern end of the Florida Reefs, about 63 miles from Sombrero Key lighthouse, and on the outer side of Carysfort Reef. Depths of 50 fathoms occur within 2 miles of the light. Observations were taken in a depth of only 3 feet, but evidently in a more exposed position than at the Tortugas station, as the effects of local influences are less apparent in the surface temperature records (Rathbun). 25° 13' N. 80° 13' W. Records from this station were obtained by Rathbun, but have not been collected during recent years.

Fowey Rocks lighthouse.—Located on the outer edge of Fowey Rocks, at the northeastern extremity of the Florida Reefs, and 23 miles from Carysfort Reef. The 100-fathom curve is distant about 2½ miles. The depth of water at the place of observation is 5 feet, and the water temperature records compare favorably with those of Carysfort Reef, indicating a similar exposure (Rathbun). 25° 35' N. 80° 06' W.

St. Johns River lightship.—Anchored about 5 miles from shore off the entrance to St. Johns River, Fla. About 57 miles from the 100-fathom contour, and about 5 miles from the 10-fathom contour, although the lightship itself is located in nearly 10 fathoms (57 feet) depth. About 305 miles from Fowey Rocks and about 110 miles from the location of the old Martin's Industry lightship. 30° 23' N. 81° 18' W. The lightship was not established in this location until January 1929.

Brunswick lightship.—Anchored in 8¼ fathoms of water, 14¼ miles 123° from St. Simon Lighthouse, Ga., and about 38 miles to the northward of the present position of St. Johns Lightship. 31° 00' N. 81° 10' W. This location, which is indicated by a small circle and dot between stations 5 and 6 in figure 1, was abandoned already in January 1929, and was not among the stations from which records were obtained during 1881-85.

Martin's Industry lightship.—Anchored in 9 fathoms of water, about 8½ miles from land, off the entrance to Port Royal Sound, 6 miles from the 10-fathom contour, and 58 miles from the 100-fathom line; distant about 110 miles from the location of St. Johns River lightship. 32° 06' N. 80° 35' W. This lightship from which Rathbun collected temperature records has now been replaced by Savannah lightship, but no data are available from this new location.

Rattlesnake Shoal lightship.—Anchored in 5 fathoms of water, about 5 miles off land, just north of the entrance to Charleston Harbor, and about 56 miles from Martin's Industry lightship. 32° 44' N. 79° 44' W. This lightship, from which Rathbun obtained his records, has now been replaced by:

Charleston lightship.—Anchored only 1½ miles SE of the location of the old Rattlesnake Shoal lightship (above) in about 7 fathoms of water, about 12 miles from the 10-fathom contour, 47 miles from the 100-fathom contour and 10 miles from the nearest shore. 32° 41' N. 79° 43' W.

For the purposes of the present report, the locations of the old Rattlesnake Shoal and the new Charleston lightships may be considered identical.

Frying Pan Shoals lightship.—During the years when Rathbun's data were collected, this lightship was anchored only about 17 miles southeasterly from Cape Fear at the 10-fathom contour, about 33 miles from the 100-fathom line. 33° 35' N. 77° 50' W. The lightship has subsequently been shifted about 15 miles to the ESE from its old position and is now anchored at the end of the outward projection of the 10-fathom contour off Cape Fear, about 30.5 miles from the latter point, about 183 miles from Charleston lightship, and only about 20 miles from the 100-fathom contour. 33° 28' N. 77° 34' W. The records for the period 1928-30 have all been obtained from the new location of the lightship.

Cape Lookout lighthouse.—The lighthouse, from which Rathbun's data were obtained, is "located on the outer shore, about 3 miles north of the extremity of Cape Lookout, and 90

miles from Frying Pan Shoals lightship. The observations were taken at the lower edge of the beach in a depth of 1 foot of water. The bottom slopes gradually, and attains a depth of 10 fathoms about 5 miles from shore. Although the maximum and minimum surface temperatures at this station correspond closely with the same at Frying Pan Shoals, the surface curves are much less regular, and show direct atmospheric influence" (Rathbun).

The records for 1928-30 were not obtained from this shore station but from:

Cape Lookout Shoals lightship.—Anchored in about 15 fathoms depth, 20 miles SSE $\frac{1}{2}$ S (163°) from Cape Lookout lighthouse, only about 2.5 miles from the ten-fathom contour and 17.5 miles from the 100-fathom curve. Latitude $34^{\circ} 18' N.$, longitude $76^{\circ} 24' W.$ Next to Diamond Shoals lightship, this is the station situated closest to the edge of the continental shelf and to the normal axis of the Gulf Stream. These two stations accordingly show great similarity in their temperature curves.

Diamond Shoal lightship.—Anchored in about 34 fathoms depth, but only about 3 miles from the 10-fathom contour, 13 miles SE $\frac{1}{2}$ E (130°) from the point of Cape Hatteras, 11 miles from the 100-fathom contour, and about 70 miles from Cape Lookout lightship. Latitude $35^{\circ} 05' N.$, longitude $35^{\circ} 20' W.$ As these figures will show, Diamond Shoals lightship is situated at the narrowest point of the continental shelf anywhere between Cape Cod, Mass., and Cape Canaveral, Fla. It also is closer to the normal axis of the Gulf Stream than any other point of observation except those in the Florida Keys. The shoals extending outward from Cape Hatteras give occasion to great turbulence in this region although the effects of this may not always reach entirely to the position of the lightship.

Body's Island lighthouse.—Located near the southern end of Body's Island, about 35 miles north of Cape Hatteras, and 86 miles from Cape Lookout. The shore is similar in character to that at Cape Lookout, but the surface observations were taken where the depths are from 7 to 9 feet. The temperature curves for the surface and air are almost precisely alike, and the observations cannot be regarded as of any value with respect to the open waters off shore (Rathbun).

Cape Charles and Chesapeake lightships.—During the period 1928-30 the lightship marking the entrance to Chesapeake Bay was first located, under the designation of Cape Charles lightship, in about 8 fathoms of water, about 9 miles from the nearest land (Smith Island), 2 miles from the 10-fathom contour and about 50 miles from the 100-fathom line. $37^{\circ} 05' N.$ $75^{\circ} 41' W.$ On September 1, 1928 the position was shifted about 6 miles to the southward and the name changed to Chesapeake lightship, under which designation it is anchored at the 10-fathom contour about 116 miles from Diamond Shoal lightship, $14\frac{1}{2}$ miles from nearest land (Cape Henry) and 50 miles from the 100-fathom contour. Since the change in location is quite insignificant for our considerations in the present report, the designation under which the temperature records were first received (Cape Charles) has also been used for the later records to avoid confusion by the comparison of the graphs for the various years. Data from the entrance to Chesapeake Bay were not obtained by Rathbun.

Winter Quarter lightship.—When Rathbun's data were being collected, this lightship was located much closer to the shore than at the present time, being anchored just at the 10-fathom contour ($10\frac{1}{2}$ fathoms) about $8\frac{1}{2}$ miles off Assateague Island, Md., in latitude $37^{\circ} 57' 03'' N.$, longitude $57^{\circ} 05' 29'' W.$ In recent years, including the period 1928-30, the lightship has been anchored about $7\frac{1}{2}$ miles East by South of its old position in about 13 fathoms of water, surrounded by shoals, about $15\frac{1}{2}$ miles off Assateague Island, about 72 miles from the 100-fathom contour, and about $68\frac{1}{2}$ miles from Chesapeake lightship.

Five-Fathom Bank lightship.—Anchored in 12 fathoms of water, about 14 miles off the coast, just east of Cape May, and off the entrance to Delaware Bay; distant about 56 miles from Winter Quarter Shoal lightship (Rathbun). Now anchored in about 15 fathoms of water, 16 miles off the coast, 55 miles from Winter Quarter lightship and about 50 miles from the 100-fathom contour.

Absecon lighthouse.—Located on the beach in front of Atlantic City, and just south of the entrance to Absecon Inlet; $34\frac{3}{4}$ miles distant from Five-fathom Bank lightship. The shore is faced with shoals, but the surface observations were taken in the channel leading to the inlet, in depths of 9 to 15 feet of water. The surface records are much more satisfactory than either of the previous shore stations (Cape Lookout and Body's Island), and the surface curves are nearly as regular as at Five-Fathom Bank lightship (Rathbun).

Sandy Hook lightship.—Anchored in 14 fathoms of water off the entrance to New York Bay;

6 miles east of Sandy Hook, N. J., the nearest land; and about 70 miles from Absecon Light (Rathbun). 40° 26' N. 73° 52' W.

Fire Island lighthouse.—Rathbun's data were obtained from the shore station (lighthouse), "located on the east side of Fire Island inlet, south side of Long Island, 31 miles from Sandy Hook lightship. The surface observations were taken in the entrance to Great South Bay, between Fire Island and Oak Island, in 3 feet of water. A strong current flows through the channel, which is somewhat similar in character to the entrance to Absecon Inlet" (Rathbun). In recent years, including the period 1928-30, the observations in this region have not been made from the lighthouse, but from:

Fire Island lightship.—Anchored in about 16 fathoms depth, 9.4 miles S $\frac{3}{4}$ E (172°) from Fire Island lighthouse, 125 miles from Five-Fathom Bank lightship, about 7 miles from the 20-fathom contour, 57 miles from 50-fathoms and about 70 miles from 100-fathoms depths. Latitude 40° 29' N., longitude 73° 11' W. The 30-fathom contour of the Hudson Gorge passes about 28 miles to the southwestward of Fire Island lightship.

Block Island southeast lighthouse.—Located at the southeastern corner of Block Island, 82 miles from Fire Island light. The observations were taken at the lower edge of the beach, which faces the open sea to the south. The surface temperature curves are comparatively regular and show less variation from local influences than would be expected at a shore station of its character (Rathbun).

Brenton Reef lightship.—Anchored in 14 $\frac{1}{2}$ fathoms of water, off the entrance to Narragansett Bay, and about 1 $\frac{3}{4}$ miles from land; 17 $\frac{3}{4}$ miles distant from Block Island southeast light; and about 80 miles from the 100-fathom contour. 41° 26' N. 71° 23' W. The point to point distance from Fire Island lightship is about 98 miles, but the projected distance of about 90 miles along the outer coastline (Long Island—Block Island—Martha's Vineyard) has been used in the graphs.

Vineyard Sound lightship.—Anchored in 15 fathoms of water, on the western side of the southern entrance to Vineyard Sound, 2 $\frac{1}{2}$ miles from Cuttyhunk Island, the nearest land, and 17 $\frac{1}{2}$ miles from Brenton's Reef lightship (Rathbun).

Nantucket lightship.—I. *Old Position.*—In earlier days, including the years 1881-85 during which Rathbun's data were obtained, Nantucket lightship was anchored in 16 to 18 fathoms, in latitude 40° 54' 51" N., longitude 69° 49' 26" W., about 21 miles SE of Nantucket Island, distant about 58 miles from Vineyard Sound lightship and about 36 miles south of Pollock Rip.

Nantucket lightship.—II. *New Position.*—In recent years, including the period 1928-30, Nantucket lightship has occupied a more southerly position on the bank, being anchored in about 30 fathoms depth, latitude 40° 37' N., longitude 69° 37' W., about 20 miles to the south-southeastward of its old position, 42 miles from Nantucket Island, 78 miles from Vineyard Sound lightship, and about 60 miles from Pollock Rip.

Pollock Rip lightship.—1881-1885. Anchored in 5-7 fathoms of water, in the eastern entrance to Nantucket Sound, and 3 $\frac{1}{2}$ miles SE by E $\frac{1}{2}$ E from Monomoy Point lighthouse, Cape Cod (Rathbun). 41° 32' N. 69° 55' W. Subsequently shifted about 5 miles to the northeastward, and now (1928-30) anchored at the 10-fathom contour NE from the entrance to Nantucket Sound, about 61 miles from the new Nantucket Shoals lightship and about 18 miles from the 100-fathom contour (Gulf of Maine). Distance from Vineyard Sound lightship, measured through Vineyard and Nantucket Sounds, about 55 miles.

Boston lightship.—Anchored in about 18 fathoms off Nantasket Roads entrance to Boston Harbor near the western shore of Massachusetts Bay, about 66 miles from Pollock Rip lightship, and 34 miles from the 100-fathom contour. In accordance with its location, the records from Boston lightship mainly reflect the strictly local conditions in Massachusetts Bay. 42° 20' N. 70° 45' W.

Gloucester, Mass.—Observations made on Tenpound Island in Gloucester Harbour. Temperatures strongly influenced by local factors.

Thatcher's Island lights.—Located on Thatcher's Island, off the eastern extremity of Cape Ann, about 73 miles from Pollock Rip lightship. Depths of 60 fathoms occur within a distance of 6 $\frac{1}{2}$ miles to the eastward. The surface temperature observations were taken where the water is 7 feet deep, and show variations from local influences. Observations were first made at this station by one of the lighthouse keepers, but after April, 1881, by an observer of the U. S. Signal Service (Rathbun). 42° 38' N. 70° 35' W.

Boon Island lighthouse.—Boon Island is a small rocky island lying off York Harbor, and $5\frac{1}{4}$ miles from the nearest land. It is distant about 35 miles from Thatcher's Island, and is surrounded by depths of $5\frac{1}{2}$ to 25 fathoms within a radius of 1 mile. The depth of water where the surface observations were taken is 9 feet. Many gaps occur in the records of this station, and the reductions plotted on the chart are therefore probably not reliable (Rathbun). $43^{\circ} 07' N. 70^{\circ} 29' W$

Portland lightship.—Anchored in about 15 fathoms of water about 5 miles ESE of Cape Elisabeth, Me., and about 3 miles from the 50-fathom contour. Distant about 18 miles from Seguin Island, about 30 miles from Boon Island, and about 80 miles from Boston lightship. $43^{\circ} 32' N. 70^{\circ} 06' W$.

Seguin Island lighthouse.—Seguin Island is small and rocky, and is situated about $2\frac{1}{4}$ miles off the nearest point of the mainland, on the eastern side of the entrance to Kennebec River, and about 47 miles from Boon Island. The lighthouse is on the western side of the island, where the water is from 6 to 8 fathoms deep close inshore at the place of observation (Rathbun). $43^{\circ} 42' N. 69^{\circ} 46' W$.

Matinicus Rock lighthouse.—Matinicus Rock is a rocky islet about 14 miles south of Vinal Haven, at the mouth of Penobscot Bay, and about 80 miles from Seguin Island. Depths of 4 to 45 fathoms occur within a radius of 1 mile, the depth where the surface observations were taken ranging from 6 to 12 fathoms (Rathbun). $43^{\circ} 47' N. 68^{\circ} 51' W$.

Mount Desert Rock lighthouse.—Mount Desert Rock is similar in character to Matinicus Rock, and is situated about 18 miles off Mount Desert Island and 34 miles from Matinicus Rock. Within a radius of 5 miles the depths range from 50 to 95 fathoms; the depths of water where the observations were taken were 2 to 10 fathoms; the records are about as imperfect at this station as at Boon Island (Rathbun). $43^{\circ} 58' N. 68^{\circ} 08' W$. Distance from Portland lightship 90 miles.

Petit Manan lighthouse.—Petit Manan Island consists of a group of low, rocky islets, situated about 2 miles from land, off the western entrance to Pigeon Hill Bay, and 27 miles from Mount Desert Rock. They are surrounded by deep water, the observations having been taken where the depths range from 8 to 15 fathoms (Rathbun). $44^{\circ} 22' N. 67^{\circ} 52' W$.

SIGNIFICANCE OF SURFACE TEMPERATURE RECORDS

The lightships and lighthouses from which the data for the present report have been obtained are generally situated above or immediately adjacent to depths of about five to about fifteen fathoms. On the whole, they may probably be roughly said to be scattered along the eight fathom contour, which has therefore been used as the measuring line for their distances from each other (see p. 24).

During winter, the surface temperatures may generally be taken to be representative of the entire column of water down to the bottom, even in depths considerably greater than ten fathoms. According to Bigelow (1927, pp. 636–667, figs. 70–73, 75, 77, 79, and 85–89) a uniform temperature, that is, temperatures with a variation of less than $1^{\circ} C$., will thus generally obtain from the surface down to 40 meters' depth or more in all regions of the Gulf of Maine and Massachusetts Bay, from about the middle or end of October to around the middle of March; and the thickness of this uniform layer will in many localities reach to a magnitude of even 100 meters or more at least during part of this period (Bigelow, 1927, pp. 663–667, figs. 86, 87

and 89). According to various midwinter observations from the southernmost part of the Middle Atlantic region compiled by Pearson (1932, table 1, p. 6) it would seem that uniform temperatures may even obtain from the surface as deep down as 200 meters (over 100 fathoms), and differences greater than 2° F. are not recorded within the upper 20 fathoms.

Since many of the lightships and lighthouses, in accordance with their purpose, are placed in locations where the topography of the bottom must cause a comparatively high degree of turbulence, and therefore a fairly complete vertical mixing, it seems probable that the surface layer of uniform temperature must on the average remain fairly thick in the immediate environment of these stations also during the summer period. It would not be reasonable to assume, however, that the vertical mixing should be sufficient to completely prevent the establishment of an effective discontinuity layer, or thermocline, at a deeper level at any of our stations, where uniform temperatures do not extend all the way to the bottom, with the possible exception of the stations within the Cape Cod-Nantucket Shoals area. Since only the surface temperatures have been recorded we do, however, not have any direct evidence as to the accurate depth for which each individual observation may be taken to be representative. From other observations we may, on the other hand, learn that although a significant temperature difference may occasionally be found to exist even within the upper five fathoms of water in such more or less protected regions as the Massachusetts Bay (Bigelow, 1927, table 17, pp. 1010-1011, stations 31, 32 and 38, cruise 14, with more than 2° C. difference between surface and 10 meters), it is safe to assume, on the basis of an overwhelming majority of all records, that such conditions will be too rare, too strictly localized, and of a too short duration⁴ to be of any general concern to us at this point. As a general rule, we may therefore take it for granted that no biologically significant deviation from the temperature at the surface will, on the average, be found to occur within the upper five fathoms of water, and the surface temperature

⁴ Such stratification close to the surface should probably be most liable to develop as a temporary condition during periods of calm weather at the time of the year when the annual surface temperature curve has just completed its steepest ascent under the influence of vernal heating. The longer the season progresses from the period of most rapid heating, the slimmer should grow the chance of finding any survival of such conditions within the layers nearest to the surface.

readings may therefore, on the whole, be considered to be directly representative of conditions down to a depth of at least 5 fathoms also during the warm season.

Below the five-fathom level, however, the deviations from the surface temperature during the summer months will undoubtedly most commonly be of a magnitude which will not permit us to regard our surface readings as direct evidence of the temperature conditions obtaining at that time in, say, 7 or 8 fathoms depth. Nevertheless, the surface temperature curve may to a certain extent be regarded as an indicator of the thermal development of the entire epithalassa (i. e., the warm surface layer found during the summer), and, in dealing with averages only, it may be reasonable to assume, as a working hypothesis, that there will be a fairly definite relationship between the general temperature level reached at the surface at any given time during the warm season and the average temperature simultaneously obtaining at any level below the surface down into the upper range of the thermocline,⁵ that is, to an average depth of probably not less than 10 fathoms during any part of the year. Until temperature readings from the deeper levels should become available on a similarly adequate scale as the surface records already obtained, it may therefore still be useful to consider the average association in time between the temperature development at the surface and the biological processes occurring also within the lower half of the upper 10 fathoms of water, although the actual temperatures under which these processes occur may be significantly lower than those read at the surface as a general indication of the seasonal stage reached by the entire epithalassa.

The local variations in the thickness of the surface layer, however, give rise to the question as to how these variations will influence the temperature at the surface itself, and as to which type of condition should be used as a basis for our consideration of geographical temperature relationships to give the ecologically most significant results.

In regard to the first question, it would, of course, seem logical to assume that the development of a thermal stratification with increased dynamic stability close to the surface must serve to limit the vertical distribution of the heat absorbed mainly in the upper layers,

⁵ Theoretically such a relationship might, of course, *ceteris paribus*, be expected to extend throughout the entire range of the thermocline down to the upper limit of the hypothermalassa.

thereby causing the surface temperature to become higher than in regions where the stratification only develops at deeper levels. From an analysis of available data it might be possible to obtain an approximate idea of the probable significance of the variations in surface temperature caused in this manner. For such an analysis to be feasible, however, it is necessary that the observations should have been made: 1) within a sufficiently short period of time to enable us to regard them as practically simultaneous so far as seasonal influences are concerned; and 2) within a sufficiently small area to discount the possible effects of geographical factors. In spite of these limitations, the records must furthermore 3) show a sufficient amount of variation in regard to thermal stratification within the depths with which we are here concerned to make any correlation which might exist between the surface temperature and the character of the stratification beneath become distinctly apparent in the observations. It is naturally not often that a set of data is obtained which will fulfill all these requirements at once, but two series of observations in Massachusetts Bay reported by Bigelow (1927, table 13, p. 995 and table 17, pp. 1004-1011) are in sufficiently good accordance with our demands to warrant some further consideration here. Bigelow's data are presented graphically in the accompanying Figure 2. In the lower part of this illustration the temperature curves at the various stations are drawn in the conventional manner, the vertical scale representing depth in meters, the horizontal scale, temperatures in degrees Centigrade. Already in this presentation it immediately becomes evident that the fluctuations in surface temperatures are not nearly as great as the variations at the deeper levels within the upper 10-15 fathoms. In the *Fish Hawk* records the surface temperatures fluctuate only within a range of about 3.5°C ., whereas the variations at 10 meters' depth cover about 6°C . and at 20 meters' depth about 7.5°C . In the *Halcyon* records the ranges are likewise about 3.5°C . at the surface, about 5°C . at 10 meters, and about 6.5°C . at 20 meters' depth. The surface temperatures thus show a much greater uniformity than do the temperatures in the lower half of the upper ten fathoms of water in the Massachusetts Bay according to these data. From the upper portion of our Figure 2 it is furthermore evident that there is absolutely no correlation between the relatively small variations which do occur also at the surface and the character of the temperature conditions below. In these two diagrams the horizontal scale represents

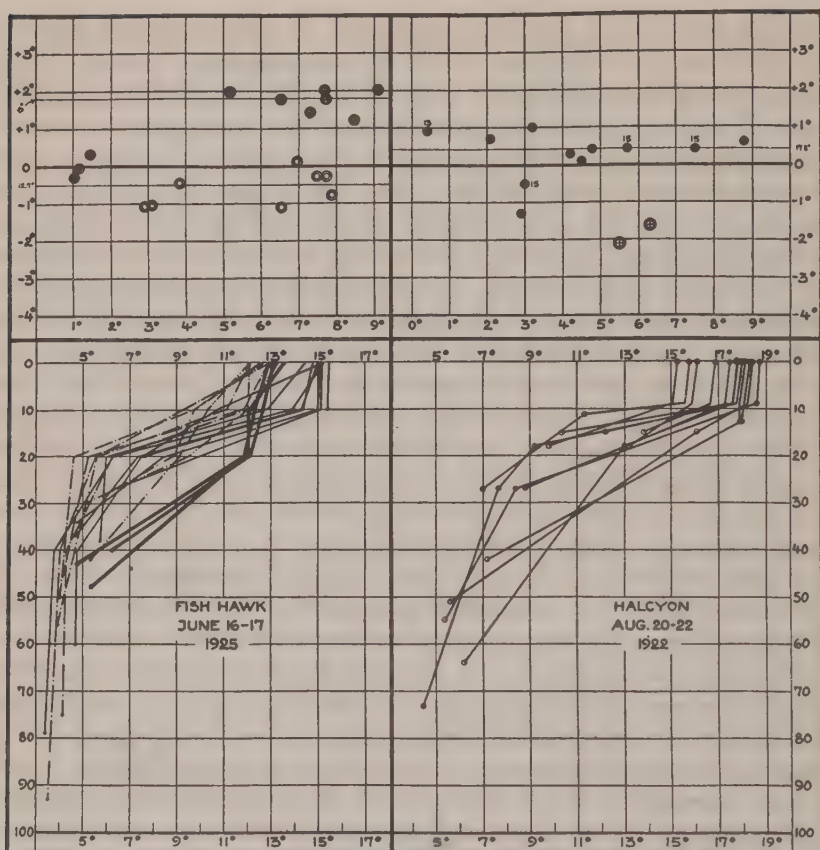


Fig. 2.—Temperature conditions in Massachusetts Bay as observed by the *Halcyon* during August 20–22, 1922 and by the *Fish Hawk* during June 16–17, 1925, according to data published by Bigelow (1927, table 13, p. 995 and table 17 [cruise 14], pp. 1004–1011). Lower section: temperature curves for each individual station.* Horizontal scales represent temperatures in degrees Centigrade. Vertical scale depths in meters. Upper section. Left: Deviation of surface temperatures at *Fish Hawk* stations from the average (13.2° C.) for stations 29, 35, and 36, with almost uniform temperatures from surface to 20 meters depth, plotted against temperature difference between surface and 20 meters depth at each station. Right: Deviations of surface temperatures at *Halcyon* stations from their total average (17.4° C.) plotted against the temperature difference between surface and 18 meters depth (10 fathoms) except where a shoaler depth is indicated by a number (13–15 [meters]) at each entry. Temperatures at 18 meters obtained by interpolation,† when not directly observed, where temperatures above and below were recorded.

* The temperature curves for the three *Fish Hawk* stations (29, 35, 36) which form the basis of comparison in the left upper diagram have been rendered in bold lines below, the curves for the stations in the inner and southern part of Massachusetts Bay (see fig. 3) in light solid lines, the curves for the stations in the northern and outer part of the Bay with dot, or two dots (3, 37, 38), and dash.

the difference in degrees Centigrade between the temperature at the surface and in 20 meters (*Fish Hawk*), or 13-18 meters (*Halcyon*) depth at each separate station; while the vertical scales represent the deviations, in degrees Centigrade, of the surface temperatures from the average of all surface temperatures in the case of the *Halcyon* records, or from the average of the surface temperatures at the three stations (29, 35, and 36), at which a practically uniform temperature was found to obtain from the surface down to 20 meters' depth, in the case of the *Fish Hawk* data. Where the difference between the temperatures at the surface and at the deeper levels is greatest, the vertical stability of the water should also be greatest; and the vertical dispersal by mixing of the heat absorbed mainly in the upper layers should be least. According to our assumption on page 12 concerning the probable influence of vertical stratification upon surface temperatures, we should therefore expect to find an increasingly positive deviation of the latter with an increasing temperature difference between the surface and the deeper layers. In our two correlation diagrams for the *Fish Hawk* and *Halcyon* records there is, however, absolutely no indication of any such relationship. It is, on the contrary, quite clear that the surface temperatures in Massachusetts Bay, at least on the occasions when these observations were made, distribute themselves evenly around their average, or around the average surface temperatures above an unstratified layer of 20 meters' thickness, regardless of the degree of thermal stratification found in the upper 10 fathoms below the surface. This rather unexpected revelation becomes even still more obvious when we consider that the Massachusetts Bay at the time of the *Fish Hawk* observations was apparently divided into two geographically differentiated temperature regions as

In the case of the *Halcyon* records, there is only one observation of the temperature in 9 meters depth (5 fathoms), at station 10633, showing a difference of only -0.1° C. from the surface temperature at the same station. For the other stations from which such data are lacking, the temperature curves rendered in fig. 2 have been drawn on the assumption that there is a decrease of only 0.2° C. from the surface down to a depth of 5 fathoms. While this may not give an accurate picture of the actual temperature curve in any particular case, it will undoubtedly give more nearly correct interpolations of the temperatures at 18 meters depth than would a straight-line connection between the surface observations and the data for deeper levels, as the latter type of curve would assume a complete absence of any layer of uniform temperature at all, and would thus give too low values for all intermediate depths.

† See second paragraph of footnote *, above.

shown in Figure 3. In the inner and southern part of the bay the surface temperatures were all higher than in the outer and northern portion, the distinction between the two regions being quite sharp, as one may see both from the lower part of Figure 2, where the temperature curves end in two separate bundles around 13° and around 15° C., respectively, and from the upper diagram where the data for the inner and southern part of the bay form a separate group from the others. If, in view of this subdivision, we compare the surface temperatures for each region separately with their own averages (12.7° C. and 15° C., respectively) it becomes even more strikingly apparent than before that there is not the slightest indication of a positive correlation between surface temperatures and degree of thermal stratification, either in the outer and northern region or in the inner and southern part. It might, on the contrary, be said that there is in both regions a faint suggestion of a decrease in surface temperatures with increasing temperature difference between the surface and the deeper layers. Exactly the same state of affairs is also seen in the *Halcyon* data, and the relationship is perhaps also in this case rendered more distinct by a comparison with an average (at 17.8° C. instead of 17.4° C.) from which the two lowest surface temperature values (below 16° C.) have been omitted. From these observations it would thus seem as though the variations in the thermal stratification beneath the surface has had no significant influence upon the temperature at the surface itself, and hence upon the representative value of surface temperatures taken at any particular point regardless of local variations in the thickness of the surface layer. It is, of course, obvious that the lack of any correlation between surface temperatures and stratification in the Massachusetts Bay on the two occasions for which we have records available is quite likely to be due to special hydrographic conditions obtaining in this area at these times. It is also clear that the material would under any circumstance be quite inadequate to permit any generalization of our findings. But the fact remains that the available records which seemed best suited to give us some inkling as to the general magnitude of the influence of local variations in stratification upon the surface temperatures above have utterly failed to show us that there is any such influence at all. The writer is not at the present time aware of any other set of records from the Atlantic coastal waters of the United States which sufficiently fulfills our three requirements of simultaneity or subsimultaneity, proximity, and variety to enable

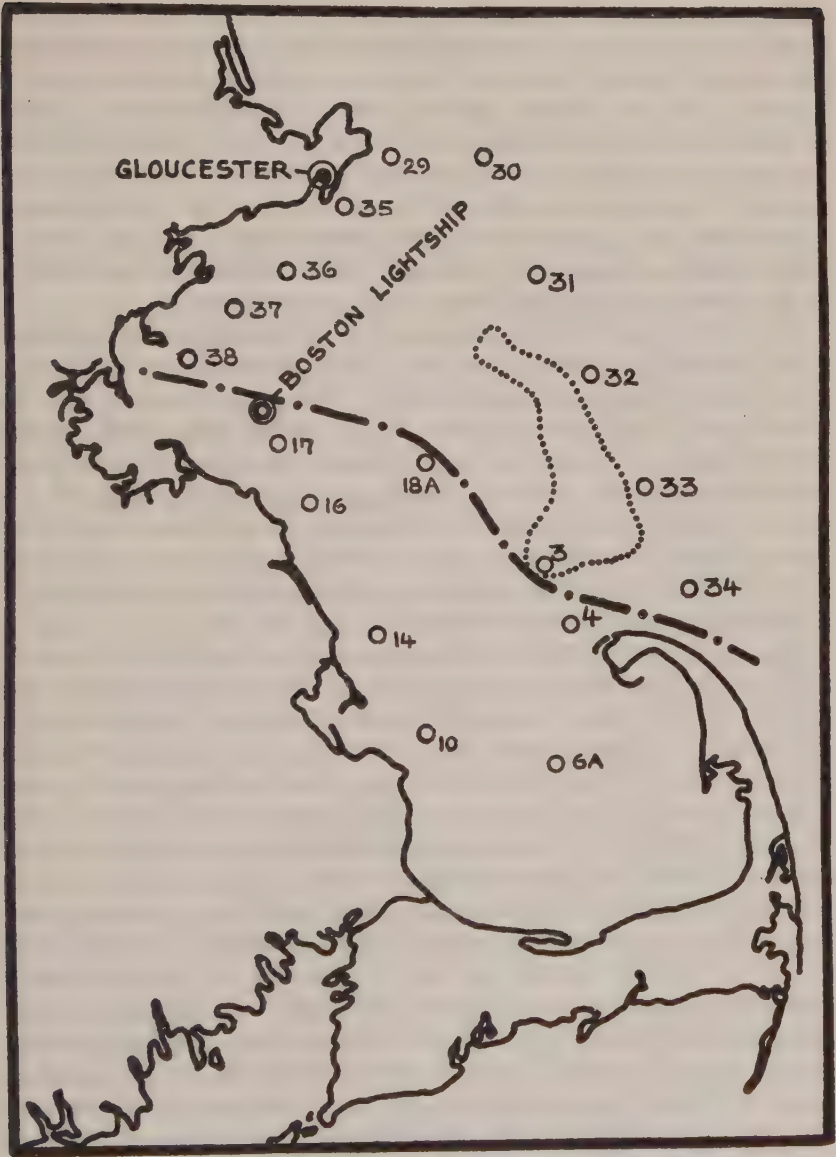


Fig. 3.—*Fish Hawk* stations in Massachusetts Bay, June 16-17, 1922, according to data published by Bigelow (1927, table 17 (cruise 14), pp. 1004-1011), with dividing line (bold dot and dash) between the outer and northern and the inner and southern temperature regions (see text). Dotted line indicates contour of the Stellwagen Bank (9-20 fathoms depth) at the mouth of the Bay.

us to pursue the question further; but it would be of interest to have such data gathered and treated statistically with a view to determining the average relationship in marine waters between surface temperatures and local variations in the thickness of the surface layer. While an analysis of this sort would probably not have any meaning for the dynamic oceanographer it would be of great value to general marine biogeography which, of necessity, will always have to deal with averages, probabilities, and generalizations for large areas and long periods, while dynamic oceanography attempts to be specific and restricted in its discussion of individual phenomena and processes.

From the scanty evidence considered in the preceding we thus have no categorical reason for assuming the existence of any systematic bias in favor of lower temperatures in the summer records from the lightship and lighthouse locations in the waters with which we are here dealing, and the author feels confident that even if further investigation should serve to reveal the presence of some slight bias of this kind, it will not be of sufficient magnitude to have any significant influence upon the conclusions drawn in this report or upon the uses to which the charts and diagrams here presented may be put in the study of the problems of marine zoogeography and ecology.

Our conclusion in the preceding paragraph may be further strengthened by a consideration of which type of location would furnish the most significant data for our biological studies in the case that a difference in surface temperature according to the thickness of the surface layer had been found to exist. Our interest on this point relates particularly to the problems of the migrating forms. During the period of rising temperature a migrating form moving northward can always avoid and circumvent an area of too high temperatures by a detour through deeper water, but there would be no escape in this manner from a region of low temperature. Inversely, during the cold season of the year it will generally be possible for the southward migrating forms to circumvent the coldest spots by resort to deeper water but there would be no way of avoiding a high-temperature area. The important points of passage would, therefore, be the locations which would show comparatively low temperatures during the summer and comparatively high temperatures during the winter;⁶ and

⁶ We are here assuming the low, respectively high, temperatures to extend right across the shallow water belt, and are not considering the problems of the comparatively few (though economically important) purely pelagic forms, for which an analysis of the shallow water conditions alone is of course quite inadequate.

if any correlation should be found to exist between surface temperatures and the thickness of the surface layer, the lowest temperatures during the summer and highest during the winter should be expected to obtain just in those regions where a relatively great turbulence prevails, such as the locations of many of the lightships and probably all of the lighthouses, from which the material for the present report has been collected. For the purpose of migration studies, these lightships and lighthouses would, therefore, under any circumstance have been our logical choice for bases of observation. The presence or absence of a systematic bias of the nature here considered would, therefore, make no difference to us in our presentation of the geographical temperature relationships with which we are here concerned since the same data would, for logical reasons, have to be selected as the basis for this presentation in either case.

In regard to the problems of the stationary populations in particular, and ecological studies in general, it must always be kept strictly in mind that the various temperature charts presented in this report are based on generalizations and averages only, and do not purport to present the actual temperature at any particular point at any particular time. The charts are, therefore, applicable only to such ecological studies as are also in their biological aspect dealing with generalizations and averages, and with geographical comparisons, but are not applicable to strictly local problems, for which local temperature records must be obtained and consulted in all cases. It should furthermore also be remembered that even as generalizations, our charts are only intended to present the temperature conditions in shallow water *off the open coast*, and that the temperatures observed in bays and inland waterways are generally higher during the summer, lower during the winter, and may, under special conditions, vary as much as nearly 20° F. from the temperatures in the corresponding locations off the open shore.

Summarizing our conclusions with regard to the significance of the surface temperature records from the lightship and lighthouse locations, we have found that they will generally be representative of a layer of uniform temperature of about 10–50 fathoms' depth, or more, during the winter. During the warm season the surface readings may perhaps not be considered directly representative of the actual temperatures down to an average depth greater than 5 five fathoms, but may indirectly be regarded as indicative of the stage of seasonal de-

velopment reached by the entire epithalassa, i. e. within at least the upper 10 fathoms of water. The possibility that the lighthouse and lightship records might be biased in favor of lower temperatures during the summer and higher temperatures during the winter, in comparison with other, less turbulent, stretches of the shallow-water zone has been considered, but the few available data having a bearing upon this problem have rather tended to disprove the existence of any such relationship, and it has furthermore been pointed out that the more turbulent locations would, particularly if such a relationship should exist, be the ones to provide us with the most significant records for our biological considerations.

For those accustomed to steeper coasts and deeper water immediately adjacent to the shoreline temperature records representative of a depth of only ten fathoms, or even somewhat less during the summer, might seem insignificant for any comprehensive consideration of the migrations or general biology of any type of living organism except the sessile bottom invertebrates. Under the special topographic conditions of the Atlantic coast of the United States south of Cape Cod,⁷ however, the shallow-water belt from the mean lower tide level down to the ten fathom contour assumes a far greater importance than usual, having an average width of slightly more than 10 miles over the entire thousand-mile stretch⁸ from Cape Cod to Cape Canaveral, Fla., thus covering an area of more than ten thousand square miles between these two points.⁹ It is furthermore within this extensive shallow water zone that by far the most important summer fisheries along the

⁷ North of Cape Cod the shallow-water zone is topographically and ecologically somewhat less important, but the surface temperature records are still of great interest to the biologist.

⁸ Measured along the outer coastline.

⁹ The following are the rough estimates of approximate lengths, average widths and areas of the various sections of the shallow water belt inside of the 10-fathom contour between the eastern end of Long Island (Montauk Point) and Cape Canaveral, Fla. All measurements in miles and square miles.

Length	Average width	Section	Area
70	1.5	Montauk Pt., Long Island, N. Y. to Fire Isl., N. Y.	105
90	4.5	Fire Isl. to Little Egg Inlet, N. J.	405
165	10.0	Little Egg Inlet to C. Charles, Va.	1,650
33	14.0	C. Charles to False Cape, Va.	462
86	4.5	False Cape, Va. to C. Hatteras	387
<u>444</u>	<u>6.8</u>	Montauk Pt. to Cape Hatteras	<u>3,009</u>

Middle and South Atlantic Coast of the United States take place. Apart from the flounders and such pelagic or semipelagic species as the mackerels, menhaden and bluefish,¹⁰ only comparatively quite insignificant quantities are, on the whole, caught beyond and below the ten fathom contour during the warm season, the bulk of the catch being actually obtained from traps situated in only about 5 fathoms depth or less. There is thus a considerable amount of evidence to suggest that several of the ecologically dominant and commercially most important species of fish, particularly of the family Sciaenidae (Weakfish, spot, croaker etc.) may have a natural inclination to stay close to the shoreline during the summer.

During the winter there is undoubtedly a general tendency to seek to slightly deeper water, but during this period our surface temperature records will also be in a general way representative of conditions down to a greater depth.

PREPARATORY TREATMENT OF DATA

To reduce the mass of data to a form in which they could be handled without too great inconvenience, the average temperatures for every five days throughout the three-year period 1928-30 have been calculated for each station, a new series of five-day periods starting from

Length	Average width	Section	Area
62	4.5	C. Hatteras to Cape Lookout	279
84	10.5	Cape Lookout to Cape Fear	882
68	20.0	C. Fear to Winyah Bay	1,360
106	16.5	Winyah Bay to Savannah	1,749
80	22.5	Savannah to Fernandina, Fla.	1,800
50	12.0	Fernandina to St. Augustine, Fla.	600
95	10.0	St. Augustine to Cape Canaveral	950
545	14.0	Cape Hatteras to Cape Canaveral	7,620
989	10.7	Montauk Point to Cape Canaveral	10,631

Inshore bays and waterways such as Pamlico Sound, Sandy Hook, Barnegat, Delaware and Chesapeake Bays etc. are not included in these estimates, and the figures above rendered therefore represent minimum values for area and average width of the various sections of the shallow water zone.

¹⁰ A considerable quantity of these species, perhaps the major portion even in their case (flounders and mackerel excepted?), is, of course, actually obtained within the ten fathom contour. Scup and sea bass do, on the other hand, also form a regular part of the commercial catches landed by ottertrawlers working in greater depths (usually about 8 to about 20 fathoms).

the first day of each calendar year. In this manner the tables were condensed from more than seven hundred single entries in the original records to only seventy-three figures for each station in each year.

The seventy-three entries for each station in each year were then plotted graphically on squared paper and an annual temperature curve, smoothed by hand, was drawn for every year and every locality. The samples given in the accompanying illustrations (Fig. 4) will probably serve to show that the amount of smoothing applied to the curves has

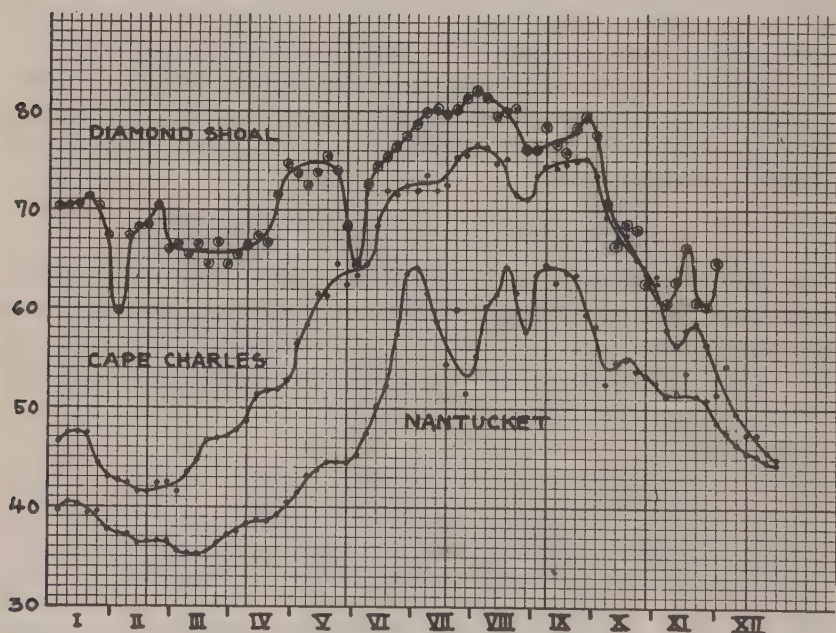


Fig. 4.—Specimen diagram of five-day average temperatures and of annual temperature curves, smoothed by hand, from the records of three separate lightships for the year 1930.

not been in excess of what was reasonably required and justified, and that care has been taken not to obscure any really significant deviations.

The five-day averages and the annual temperature curves thus obtained have formed the basis for all our further considerations of the temperature records with which we are here dealing.

In Rathbun's temperature charts the annual curves are already

based upon ten-day averages and no further treatment of his data has therefore been required for the purposes of the present report.

Since Rathbun's data as well as the records from recent years have all been rendered in degrees Fahrenheit and since this is the temperature scale with which the fishermen and the practical investigators of these waters are most familiar and which they are most apt to use, it has been found convenient and advisable to retain this form of expression for the temperature data discussed on the following pages. A table for conversions to degrees Centigrade is given at the end of this article.

PRINCIPLES AND METHOD OF PRESENTATION

One of the most urgent needs of the marine biologist engaged upon the study of the zoogeography and ecology of the shallow water zone, particularly in regard to the problems of its migratory populations, is that of a clear and unified picture in which the seasonal changes in environmental conditions are shown at once in their relationships both to time and to geographical location. Various methods of achieving this purpose seem possible, and among these chiefly two may require our further consideration here. By both methods we are mainly concerned with the problem of how to present geographical location and distances in the manner which will give the greatest general validity to the conclusions which we might derive from our consideration of the relationship between environmental conditions, represented in this case by the temperature, and the time and location of the biological processes going on in the sea.

The method which at first thought might seem to present our data in the simplest and most generally significant manner would be that of projecting our observations to a single meridian, so that our figures, in other words, would correlate temperature, time, and latitude, but would leave the actual location and the true distances between the points of observations entirely out of consideration. This method of presentation might possibly be useful for hydrographical considerations, if we intended to bring out any direct influence from astronomical factors, chiefly from the variations with latitude in the relative position of the sun at different times of the year. For biological purposes, however, this form of presentation would probably prove less useful because it does not deal with the real conditions of the shallow water zone, but projects the environmental factors of this region to

hypothetical positions, which have no relations at all to reality and to the location of the organisms living under the observed conditions. Similarly, the actual temperature gradient, which might be supposed to govern the movements of the migratory forms of the shallow water belt, would be greatly distorted by projection to a single meridian, since the interval between isotherms would be foreshortened as the deviation of the coast line from the meridian increases. The migrating animals, however, are, of course, only concerned with the gradients they encounter in the path of their migrations. This, and not the hypothetical gradient according to latitude, would therefore give us the features which should be most important in our biological considerations of the migratory forms.

The ideal requirement would be to have the seasonal fluctuations in environmental conditions, both in regard to temperature and to other factors, plotted against actual distances along the true route of travel of any particular species we might want to consider, regardless of whether this would extend our line of measuring from the depths to the surface, or vice versa, or on a horizontal level; whether along a meridian, or a coast line, or in intermediate waters; whether the line would be straight, or curved, or even involute. Only from data correlated in this manner will it be possible to arrive at any definite and final conclusion concerning the significance of each particular factor in determining the movements of the migratory species.

Without adequate information as to the true route of travel of any particular species it seems most probable that the gradients determined along the shallow water belt itself would be of the greatest general significance for the movements and general biology of the inhabitants of this ecological zone. The illustrations accompanying this report, to show the temperature conditions in the shallow water zone along the Atlantic Coast of the United States, have therefore been drawn according to true distances along the eight fathom contour,¹¹ in the manner that the intersection points between the annual temperature curves for each separate locality in each year (see p. 22) with the abscissae for each two degree's temperature (Fahrenheit) have been entered on the position line of the respective lighthouses and lightships, and the isotherms combining corresponding

¹¹ The eight fathom contour has, of course, not been followed into the various bays such as the Chesapeake and the Delaware, but only along the open coast and from point to point across the entrances of these bays.

temperature points on these various station lines have then been drawn in the simplest way permitted by the data. When graphs of this sort are prepared there will frequently be a choice between two or even three different ways in which equal temperature points could logically be combined with each other, the question generally being whether they should be combined by one continuous, and then very sinuous, isotherm or by one continuous isotherm and by one or more closed isothermal rings suggesting the independent appearance on repeated occasions of water of this particular temperature in the special locality considered. In most cases, the question of how to draw the isotherm is definitely decided by the consideration of the records from more than two stations at a time. Thus, for instance, the data from Gloucester and from Boston Bay might show the presence of temperatures as high as 66 degrees F. or more simultaneously with similar temperatures between Fire Island and Brenton Reef, indicating a possible temperature continuity between these two areas which, however, would be disproved by the failure of the temperature curves at the two intermediate stations of Pollock Rip and Nantucket to reach to the same high level. Special details applying to the drawing of each particular figure will be given in their legends. Generally it might be said that almost no smoothing at all has been applied to these figures except on certain occasions when the Gloucester records have not even been in agreement with the records from Boston, and when the special conditions observed at Gloucester may therefore be assumed to have been so strictly local in nature as not to require any further consideration here.

TOPOGRAPHICAL CONSIDERATIONS

The continental shelf along the Atlantic Coast of the United States is naturally divided into three separate sections. A southern section from The Straits of Florida to Cape Hatteras; the Middle Atlantic section between Cape Hatteras and Cape Cod; and a northern section, or the Gulf of Maine, north of Cape Cod.

Southern and Middle Atlantic Regions.—In the Southern and Middle Atlantic Sections we recognize two areas of essentially the same topographical character, separated from each other by the constriction of the continental shelf in the prominent region of Cape Hatteras. Each section consists of a wide crescent bight with a generally sandy, smooth and even bottom, and sandy or marshy shores. In the cen-

tral portion of each section the continental shelf attains to a very great width; about 75 miles off the coast of Georgia in the southern section and about 90 miles off northern New Jersey and western Long Island in the Middle Atlantic section, the width being reckoned to the 100 fathom contour. In the southern section the width of the shelf gradually tapers away in both directions, being reduced to only about nine miles at Jupiter Inlet, Fla., which may be regarded as the southern limit of this region, and to about 19 miles in the region of Cape Hatteras at the northern end. North of Cape Hatteras the shelf again expands very gradually into the bight of the Middle Atlantic section, which extends in a North-easterly direction to the shoals of Nantucket and the prominence of Cape Cod with the adjacent islands.

Cape Cod-Nantucket Shoals Area.—While the boundary region of Cape Hatteras, separating the Southern from the Middle Atlantic section, is of a topographically very simple character, the region of Cape Cod and Nantucket Shoals, separating the Middle Atlantic Coast from the Gulf of Maine, is of a far more complicated nature and may therefore require some further consideration here. As the accompanying outline chart (fig. 5) will show, this boundary area offers the possibility of at least two topographically separate paths for the passage of migrating forms in either direction, namely through Nantucket Sound, by the inner route, or over Nantucket Shoals on the outside. Entrance or exit from Nantucket Sound to the Westward might be effected through several different openings, particularly Vineyard Sound and Muskeget Channel, but since there is only one opening from Nantucket Sound to the eastward (and northward) towards the Gulf of Maine the question of the possible western entrances or exits remains a purely local problem which need not concern us here. The entire inside route can therefore be dealt with as a simple path, judged on the basis of conditions at its eastern opening, in our consideration of the possible passages from the Middle Atlantic region into the Gulf of Maine. Two problems then confront us. First to attempt to determine whether there would be a biologically significant difference in the conditions encountered along the inside or outside routes at any time of the year. Secondly to make a selection of one of these routes as a basis for our graphical presentation of the annual temperature cycles in the shallow water zone since the two routes show a considerable difference in length which would be reflected in the vertical scale of distances in these graphs. In the accompanying

figure 6 the temperature conditions observed at Pollock Rip and at Nantucket Lightship are exemplified above by the unsmoothed annual curves, on the basis of five day averages, for the year 1930 and sum-



Fig. 5.—Outline chart of the region of Cape Cod and Nantucket Shoals, showing the new and old position of the Nantucket Lightship and the locations of the other lightships from which records have been obtained from this area. The thin solid line over the Nantucket Shoals indicates the outline of the cold water area in this region (57.2° – 60.8° F.) according to Bigelow (1927, fig. 46, p. 587), the thin broken line with hatchings representing another possible outline of the same according to the suggestions made on page 26 in the present report.

marized below by the average annual curves for the periods 1881–85 (Rathbun's date) and 1928–30. It is at once apparent from the upper curves in this diagram that conditions in regard to temperature may

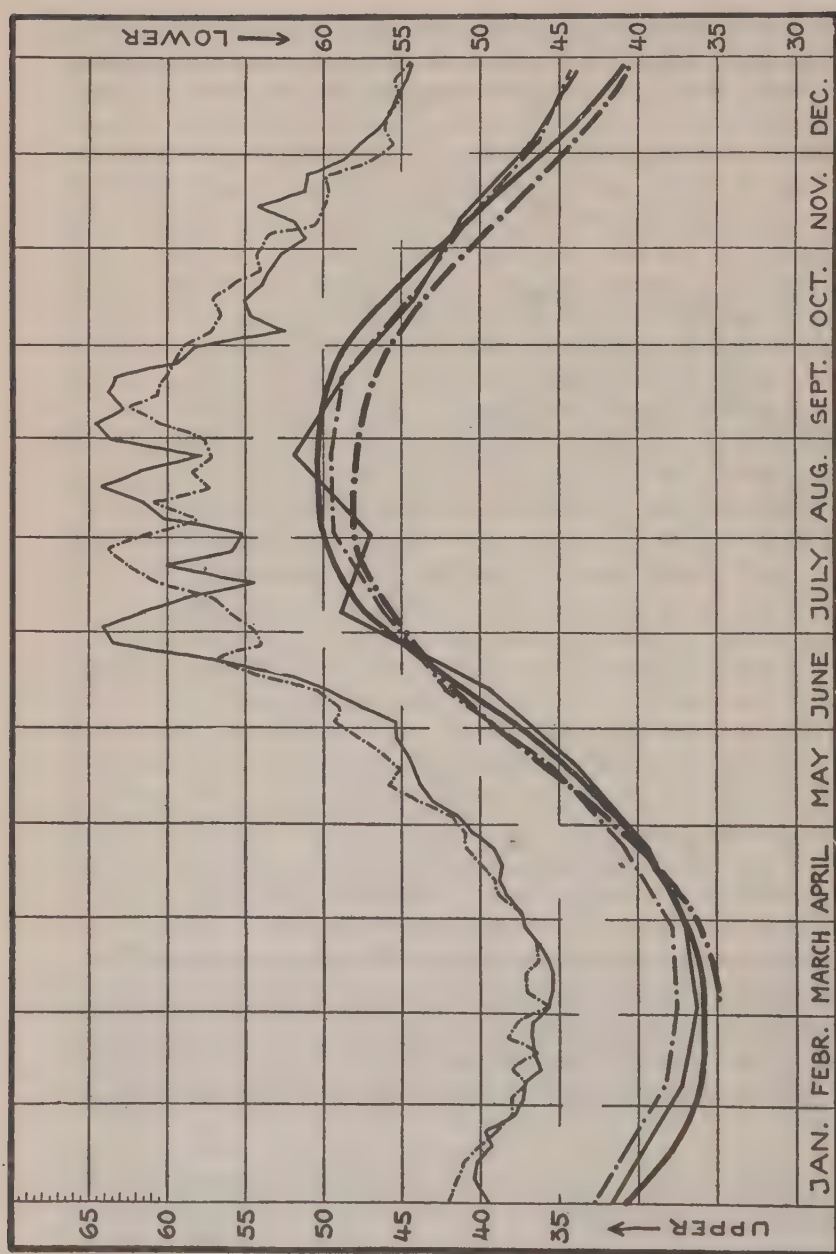


Fig. 6.—Temperature curves for Pollock Rip (dot and dash) and Nantucket (solid lines) Lightships. Upper diagram: Unsmoothed curves on the basis of five-day averages for the year 1930. Scale in degrees Fahrenheit at the left. Lower diagram: Smoothed curves in heavy lines and dot-and-dash based upon ten-day averages for the five-year period 1881-85, according to Rathbun's data. Light unsmoothed temperature polygons based upon 20-day averages for the three-year period 1928-30 (original data). Scale in degrees Fahrenheit at the right.

be widely different in the two localities here compared at any given time. Towards the end of June 1930 we find the surface temperatures at Nantucket Lightship about ten degrees higher than at Pollock Rip, but towards the end of July in the same year this relationship has reversed itself and we now find the temperatures at Pollock Rip about six to eight degrees higher than at Nantucket. There is thus nothing constant or permanent either in the direction or in the magnitude of the temperature differences between these two localities. Passable temperatures may be encountered at Pollock Rip while impassable ones obtain at Nantucket Lightship, and vice versa, but if we study the curves of averages for the period 1928-30 in the lower part of our diagram we see that the chance of passage with any given temperature requirement would be exactly the same at both points. When the irregularities which still remain even in the curve of twenty-five day averages for Nantucket Lightship are smoothed by a moving average of three the resultant curve does not at any point deviate by as much as one degree Fahrenheit from the average curve for Pollock Rip during the same years.

In the average curves for 1881-85 obtained from Rathbun's temperature charts (Rathbun 1887, Ocean Temperature Charts No. 18 and 19) there is a consistent difference between Pollock Rip and Nantucket Lightship in their old positions, the average surface temperatures in the former location being invariably somewhat lower than in the latter. This difference first appears in the beginning of July and reaches an average magnitude of about two degrees Fahrenheit during that month. During the subsequent months it slowly increases as shown in the smoothed curves to about three degrees Fahrenheit at the end of September and beginning of October, whereafter it again decreases to about two degrees Fahrenheit at the end of October and about one degree Fahrenheit in the first days of December.

Since the available data for this report have thus either failed to show any significant difference between the average temperatures at Pollock Rip and at Nantucket Lightship, or shows a difference which would only be in accordance with the geographical sequence of the stations under any arrangement, it was decided to include the Nantucket records in our temperature charts (figs. 8-11 and 13-14) and to measure the distances around the outside of Nantucket Island since this gives the best spacing and most natural arrangement of the stations on our vertical scale of distances, and therefore also provides the

clearest picture of the temperature relationships with which we are here concerned.

It should always be kept in mind, however, that the proper temperature at Pollock Rip might make it possible to pass from the Middle Atlantic region into the Gulf of Maine by the inner route through Nantucket Sound, while passable temperatures southeast of Nantucket Island would require to be simultaneously or subsequently supplemented by similar temperature conditions at Pollock Rip to make possible the completion of an outside passage so far as migrations within the shallow water belt are concerned. Temperature conditions at Pollock Rip may therefore have a special significance for our considerations independent upon the temperatures obtaining at Nantucket Lightship, whereas no such independent significance attaches to the latter. For this reason fig. 12 on page 43 has been drawn to indicate the temperature conditions for an inside passage from the Middle Atlantic region to the Gulf of Maine, by way of Nantucket Sound for each of the three years 1928-30 in so far as these conditions are revealed in the records from Brenton Reef, Pollock Rip, Boston and Portland. A comparison with figures 8-10 will show the difference in the possibilities offered by the inside and by the outside routes for passage at a certain minimum temperature. It will be noticed that there is perhaps a general tendency for a somewhat better, and longer lasting, chance of passage at 60° F. or higher to develop along the inside route than around Nantucket Lightship (see page 44). This difference is not due to higher summer temperatures at Pollock Rip than at Nantucket, but to the requirement of double coincidence, or reasonable sequence, of the higher temperatures at Nantucket both with those of the Middle Atlantic stations *and with those of Pollock Rip*, when the outer passage is considered. In the case of the inner route the summer temperatures will, on the other hand, always be higher on both sides of Pollock Rip, due to a generally higher level of temperatures along the Middle Atlantic Coast to the westward and southward, and to the special effectiveness of the vernal heating in Massachusetts Bay to the north, so that a relatively high temperature at Pollock Rip will always, *ipso facto*, establish the possibility¹² of a

¹² A possibility so far as our available evidence goes. Reservations must always be made for our lack of knowledge about simultaneous conditions in the regions between our points of observation. But this reservation will always be applicable to our considerations, however densely we might arrange our stations, and it is therefore not an argument against our conclusions, but merely a reminder of their limitations.

complete passage at this temperature or higher at least to the waters of Massachusetts Bay. Thus in 1929 a temperature of 60° F. or higher occurred at Boston, at Pollock Rip and at Brenton during July, and established a temperature continuity by the inside route towards the end of that month, whereas 60° F. or higher did not occur¹³ at Nantucket Lightship until the end of August, when the temperature at Pollock Rip was less than 58° F. and remained lower for the rest of the season, so that a temperature continuity at 60° F. along the outer route was not established at all during this year.

In connection with our discussion of the possible differences in the relative significance of the inside and outside passages through the Cape Cod-Nantucket Shoals boundary region it is important to mention the frequent occurrence, or possibly permanent presence during the summer, of a cold area of upwelling water southeast of Nantucket Island, which was brought to the writer's attention in this connection by Dr. Bigelow, who was also the first to describe the phenomenon (Bigelow 1927, p. 594). The outlines of this cold area over Nantucket Shoals has been entered in our figure 5 in accordance with the chart rendered by Bigelow (1927, fig. 46, p. 587). It will be noticed that the area is shown to include the old, but not the new, location of Nantucket Lightship and it was therefore expected that a comparison of the recent records from Nantucket Lightship in its new position, well apart from the center of upwelling, with Rathbun's data from the old location might serve to shed some light upon the importance, extent, constancy, or frequency of occurrence, of the cold water at the surface over Nantucket Shoals. As a glance at figure 6 will show there does, however, not appear to be any significant difference between the surface temperatures in the two locations, at least not in the expected direction, in so far as the records from these two separate periods are really comparable with each other. If the data for recent years are smoothed by a moving average of three¹⁴ it would, as a matter of fact, seem as though the surface temperatures during the summer months maintained an average about 1° F. higher in the old location of Nantucket Lightship than in the new. A comparison of our own records with Rathbun's data does therefore not contribute much to the elucidation of our problem except to the extent of rather definitely indicating that

¹³ In the five-day averages.

¹⁴ Making the Nantucket curve for 1928-30 practically indistinguishable from the Pollock Rip curve for the same period throughout the warm season (see page 29).

the surface temperatures in the old location has not been under any stronger influence from the upwelling of deeper water over Nantucket Shoals than are the surface temperatures at the lightship in its new position today. If temperatures of less than 16°C. , or 60.8°F. , at the surface during August are indicative of such influences, however, as shown in Bigelow's chart, we furthermore find that both the old and new locations of Nantucket Lightship, and *Pollock Rip as well*, must be included within the average boundaries of this cold area since the peaks of the smoothed average curves for all of these locations fall below this limit, both during the period of 1881-85 and during 1928-30. The fact that the average summer temperatures in the old position of the Pollock Rip Lightship were significantly lower than in the new location of this station may also be taken to indicate that the old location must have been more completely within the boundaries of the cold area, as suggested in figure 5. In Bigelow's chart the cold area is defined by temperatures from 14 to 16°C. ($= 57.2$ to 60.8°F.), and in Rathbun's data we find the five-year average for Pollock Rip barely rising above the minimum of this temperature range. Both at Pollock Rip and at the new location of Nantucket Lightship, however, these low values represent the averages, only, of rather violently fluctuating temperatures¹⁵ tending to show that these two stations are probably normally situated at the northern, respectively southern, boundaries of the cold area. In the temperature curves for the year 1930 there is an apparent tendency for the high temperatures to alternate in their appearance at Pollock Rip and at Nantucket Lightship, indicating a shifting back and forth of the entire cold area, rather than a contraction and expansion. Similar alternation is also indicated in the curves for the earlier years, notably during June and the first half of July, and again during September 1928, and from August (July ?, see figure 7) to the beginning of October 1929, as shown in figure 7. But there are also cases of coincident occurrence of highs or lows in both locations, suggesting that expansions and contractions of the area of cold water may also take place. A most conspicuous instance of simultaneous highs, indicating contraction of the cold area, may be seen in the temperature curves for the last half of August 1928, while

¹⁵ This irregularity was also noticed by Rathbun in his temperature curves for Pollock Rip and mentioned in his explanation of ocean temperature chart no. 19 (Rathbun 1887, p. 212), but was not found in his curves for Nantucket lightship in its old location (see above).

simultaneous lows are recorded for the last half of July during the same year, for the first half of August 1929 and in the last half of the latter month in 1930. It thus appears that both shifts and expansions or contractions of the cold area may occur at different times, and the hatched broken outline shown in figure 5 on page 27 might perhaps

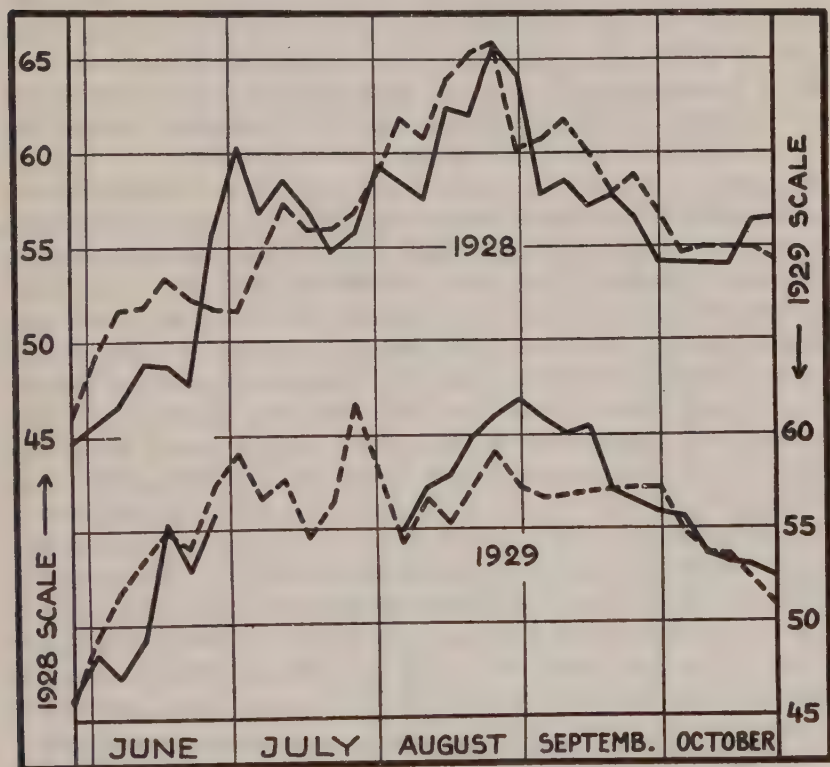


Fig. 7.—Unsmoothed temperature curves based upon five-day averages for Pollock Rip (broken lines) and Nantucket Lightships (solid) during the summer periods of 1928 and 1929. Data for Nantucket Lightship missing for July, 1929.

best be said to represent the probable average range of the cold water area, as indicated by average maximum temperatures of less than 60.8° F. (16° C.), while a distribution of the cold water such as that indicated by Bigelow (1927, fig. 46, p. 587; see fig. 5 page 27 in the present report) is very likely to occur in specific cases. In regard to conditions at the old position of Nantucket Lightship it is very inter-

esting to note that Rathbun (1887, Explanation of Ocean Temperature Chart No. 18, p. 210) found that "the temperature of the surface water [was] much more equable [in this location] than at any of the preceding stations north of the Florida Reefs." This observation would seem to indicate that the old location must have been well within the boundary of the cold area, beyond the range of the marginal fluctuations, but the fact that the average summer temperatures shown in Rathbun's diagrams for Nantucket lightship come very close to the maximum for the cold area is rather in contradiction of this conclusion. What the proper answer to this puzzle might be must be left for the physical oceanographers to decide.

If a pool of cold upwelling water is always present at the surface in the Nantucket Shoals region and the temporary appearance of higher temperatures at Nantucket Lightship merely means that this pool has contracted or shifted a little to the northward, then these occasional high temperatures at Nantucket Lightship would not be of any significance for our discussion of the conditions offered by the outside passage through this region, as the cold water would still be there to block the path *between* Nantucket Lightship and Pollock Rip.¹⁶ On this basis the possibilities of the outside passage could better be judged by the temperature-lows at Nantucket Lightship, with total disregard for all higher values, since these lows might be assumed to represent conditions which would always be found to obtain somewhere between Nantucket Lightship and Pollock Rip. The temperature barrier in the Cape Cod region (see page 44) would thus acquire a much more formidable aspect, so far as the outside route is concerned,¹⁷ than that shown in any of our graphs, but the loophole through Nantucket Sound would still, so far as we know, be opened

¹⁶ According to unpublished observations kindly made available by Dr. Bigelow, it would seem that the maximum summer temperature in the central part of the cold area will probably, on the average, not exceed 11° Centigrade, or only about 52° on the Fahrenheit scale.

¹⁷ There are unfortunately no observations to show whether the cold area over Nantucket shoals actually extends to the outer coast of Nantucket Island, or whether it leaves an inner belt of warmer water immediately adjacent to the shoreline. Until this question has been settled, one must, of course, consider the possibility that such a belt may exist, and may render an outside passage possible at somewhat higher temperatures than those observed in the more central portions of the cold area. The biological evidence from the summer distribution of the migratory species, however, clearly point to the existence of an effective temperature barrier in the region of Cape Cod.

for passage into Massachusetts Bay every time a sufficiently high temperature is to be found in the region of Pollock Rip. Our figures 8-11 and 13-14 would therefore also under these circumstances still remain fully representative of temperature conditions along the inner route, which is topographically just as accessible to the migrating forms as is the outer passage. The usefulness of our charts thus suffers no reduction due to the development of these special conditions southeast of Nantucket Island, and it must suffice for the purposes of the present report to have called attention to their existence, and to have shown their possible bearing upon our problems in this manner.

Massachusetts Bay and the Gulf of Maine:—North of the boundary area of Cape Cod and Nantucket Shoals¹⁸ we encounter topographical conditions entirely different from those obtaining both in the Southern and in the Middle Atlantic regions. While great regularity of contours prevailed in the two southern sections the contours both of the shore line and of the isobaths for deeper levels become increasingly complex and irregular as we proceed northward from Cape Cod. Simultaneously the nature of the shores as well as the seabottom in shallow water undergoes a change from that of the almost unbroken 1000 mile stretch of sand south of Cape Cod¹⁹ to an increasingly rocky character, rocks both above and below water becoming generally predominant over sand from northern New Hampshire northward. Accompanying these changes in character is also a great reduction in the average width of the shallow water zone as defined by the ten-fathom contour. Due to the irregular contours already above mentioned accurate values are very difficult to obtain, but even in the shallow Massachusetts Bay the average distance from the shore line to the ten-fathom contour is certainly less than four miles, perhaps even less than three, although a distance of about $8\frac{1}{2}$ miles may be measured locally in the southeast corner of Cape Cod Bay. North of Massachusetts Bay, from Cape Ann to Cape Elizabeth, Me., the

¹⁸ The southeastern boundary of the Gulf of Maine is completed by George's Bank, extending about 180 miles to the ENE of Nantucket Island, as measured to the 50 fathom contour. The Bank rises above the 10-fathom level only in scattered and very restricted areas widely separated from the coastwise shallow-water belt and need therefore not be included in our consideration of this ecological zone.

¹⁹ More accurately south of New York, the change already beginning to become apparent along the coast of Southern New England between New York and Cape Cod, while Cape Cod itself is again chiefly sandy.

average width is certainly less than two miles, perhaps not over $1\frac{1}{2}$; and from Cape Elizabeth to the Bay of Fundy (Canadian boundary) probably less than one mile. The numerous islands and bays along the torn coastline of Maine of course greatly increases the length of the shallow water belt, thus compensating to some extent for its lack of width, but, even so, this torn area, land and sea included, may be judged to have an average width not in excess of fifteen miles, when the entire stretch between Cape Elizabeth and Passamaquoddy Bay (Canadian boundary) is considered as a whole. Of this fifteen miles wide strip, land (including islands) obviously occupies by far the greatest area and water deeper than 10 fathoms occupies at least as much, if not more, than the shallow water zone. If the shallow water zone between mean low water level and the ten-fathom contour is therefore considered to represent about one-fifth of the fifteen miles wide strip, its actual dimensions are probably not minimized nor is there reason to believe that they will be greatly exaggerated. On the basis of these figures we arrive at the following rough estimates of the probable area of the shallow water zone along the United States' shore of the Gulf of Maine.

Section	Approximate Coastwise length	Maximum possible area within 10 fathom contour	Probable area within 10 fathom contour
Massachusetts Bay	100 miles	400 sq. miles	300 sq. miles
Cape Ann to Cape Elizabeth	80 miles	160 sq. miles	120 sq. miles
Cape Elizabeth to Canada	160 miles ²⁰		480 sq. miles
Totals	340 miles	1040 sq. miles	900 sq. miles

These figures are, of course, not nearly as accurate approximations as were those given in footnote 9 on page 20 for the dimensions of the shallow water zone south of Cape Cod.

In the case of Massachusetts Bay the writer was at first in doubt as to whether it should be dealt with separately as a marginal sea or included in our considerations of the shallow water zone off the open

²⁰ Measured on a line between prominent points only, not following the indentations of the coastline.

coastline. The latter procedure was decided upon for the reason that the Bay is too wide at the mouth (about 36 miles), especially in comparison with its very slight length (only about 22 miles, or less, measured as an indentation in a southwesterly direction) to warrant the assumption that it would, or could if conditions required, commonly be eliminated from the traveling route of the migrating forms by a direct course across its mouth. Such a route may of course frequently be taken, but it is a simple matter to eliminate the effect of the Massachusetts Bay data upon the seasonal course of the isotherms in our charts if such elimination should be required for a consideration of the possibilities of a direct passage across the mouth of the Bay. If, on the other hand, the Massachusetts Bay data were excluded beforehand from our graphs it would leave an unwarranted hiatus²¹ in our considerations of the actual continuity of the shallow water zone and would seriously limit the usefulness of our presentation of its temperature-relationships.

Our presentation of temperature conditions in Massachusetts Bay are almost exclusively based upon the records from Boston Lightship which would seem to be rather ideally located to give a picture of average temperatures within the Bay²² so far as one single station is able to give such a picture. The temperatures observed in Gloucester harbour are too strongly influenced by purely local factors to be of any general value, except when, by complete agreement with the Boston Lightship records, they may indicate an extension of the conditions also found in the latter locations. Only in such cases, however, have the Gloucester records been given any consideration in our charts.

SCOPE AND LIMITATIONS OF CONSIDERATIONS

As already mentioned in the introduction it is the purpose of the present report to attempt to make a general presentation of temperature conditions in shallow water along the entire eastern coast of the United States from Tortugas to the Canadian boundary, so far as

²¹ The relationship of a short, wide open bight like Massachusetts Bay to the migrating paths and ecological sequences off the open coastline is obviously entirely different from that of long narrow, or at least narrow-mouthed, indentations such as the Chesapeake and Delaware Bays.

²² Notice for instance its position just at the boundary line between the northern and southern surface temperature areas in our chart of the Fish Hawk observations during June 16-17, 1925, in figure 3 on page 17.

the material will permit. Since, however, the entire physical oceanography of the Gulf of Maine, including, of course, the temperature conditions there, has already been so excellently and exhaustively dealt with by Bigelow (1927), and since, on the other hand, our information about temperature conditions in the southern Atlantic section, south of the Carolinas, is relatively less complete, it will not be necessary in the case of the former region, and not possible in the case of the latter, to carry our considerations into the same detail as for the Middle Atlantic section of the shallow water belt, with its northern and southern boundary regions, which will therefore receive the greatest attention in this report.

ANNUAL GEOGRAPHICAL TEMPERATURE CYCLE

MIDDLE ATLANTIC REGIONS. GULF OF MAINE. *Records from 1928-30.*—As Figures 8-13 will show, the annual temperature history of the shallow-water zone between the boundary regions of Cape Hatteras and Cape Cod-Nantucket Shoals apparently repeated itself on the same general pattern every year, at least during the three years 1928-1930. At the beginning of each calendar year we find the isotherms from about 45° to about 60° or even 70° F. running very close together in the neighborhood of Cape Hatteras.²³ The isotherms in this group (45-70° F.), especially those of the higher temperatures therein, generally form a very complex pattern, indicative of the violent fluctuations which occur in the region immediately south of Cape Hatteras during the winter period, a phenomenon which will be discussed in greater detail on page 49. North of Cape Hatteras the winter temperatures are very uniform along the whole coastline, and there is an open continuity between temperature conditions north and south of Cape Cod²⁴ without any barrier at all at this point during the cold season.

Although the lowest temperatures (40° F. and less) already begin to recede very rapidly to the northward at the end of February or the beginning of March, the general effect of the approaching spring over the entire range of temperatures only begins to become significant around the middle of April. At this time the closely-grouped iso-

²³ Cape Hatteras is located immediately northwest of the Diamond Shoal lightship (see figure 1 on page 6).

²⁴ The Cape Cod region as here understood is represented in each temperature diagram by the area between Nantucket and Pollock Rip.

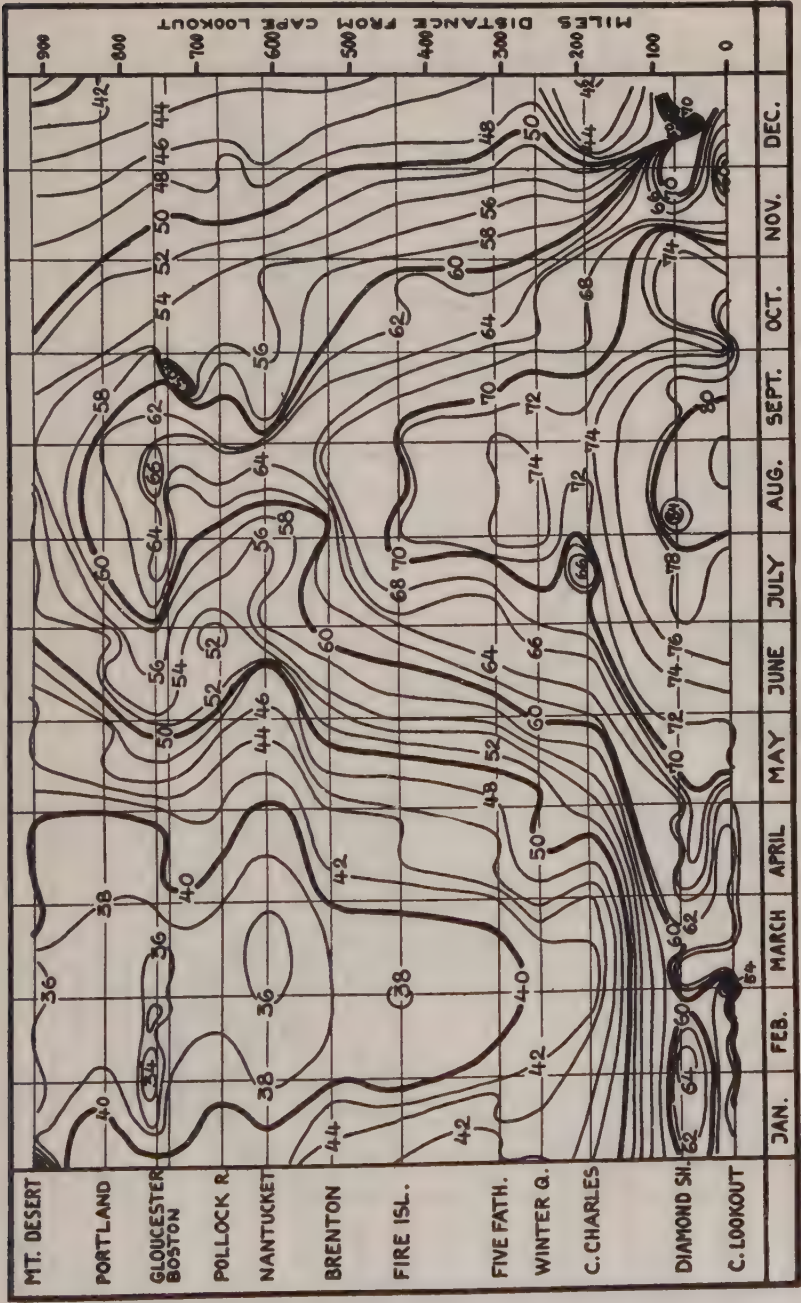


Fig. 8.—Seasonal course of isotherms for every 2 degrees F. during 1928, in shallow water along the Atlantic coast of the United States, plotted according to distances measured along the eight-fathom contour. Drawn to show conditions along the outside route in the Cape Cod region (SE of Nantucket Island). For conditions along the inside route by way of Nantucket Sound see figure 12. Positions of lightships and lighthouses on the left. Distances from Cape Lookout on the right.

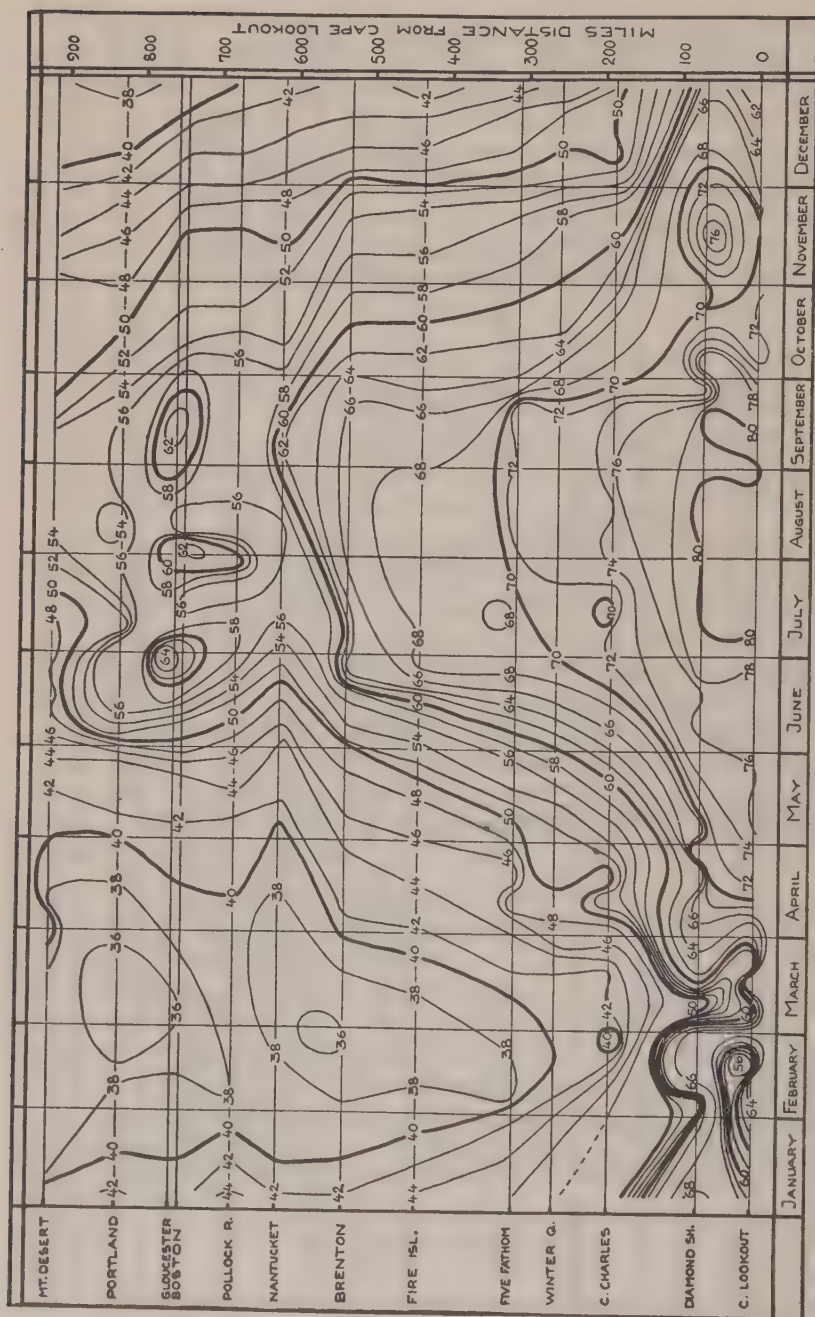


Fig. 9.—Seasonal course of isotherms for every 2 degrees F. during 1929, in shallow water along the Atlantic coast of the United States, plotted according to distances measured along the eight-fathom contour. Drawn to show conditions along the outside route in the Cape Cod region (SE of Nantucket Island). For conditions along the inside route by way of Nantucket Sound see figure 12. Positions of lightships and lighthouses on the left. Distances from Cape Lookout on the right.

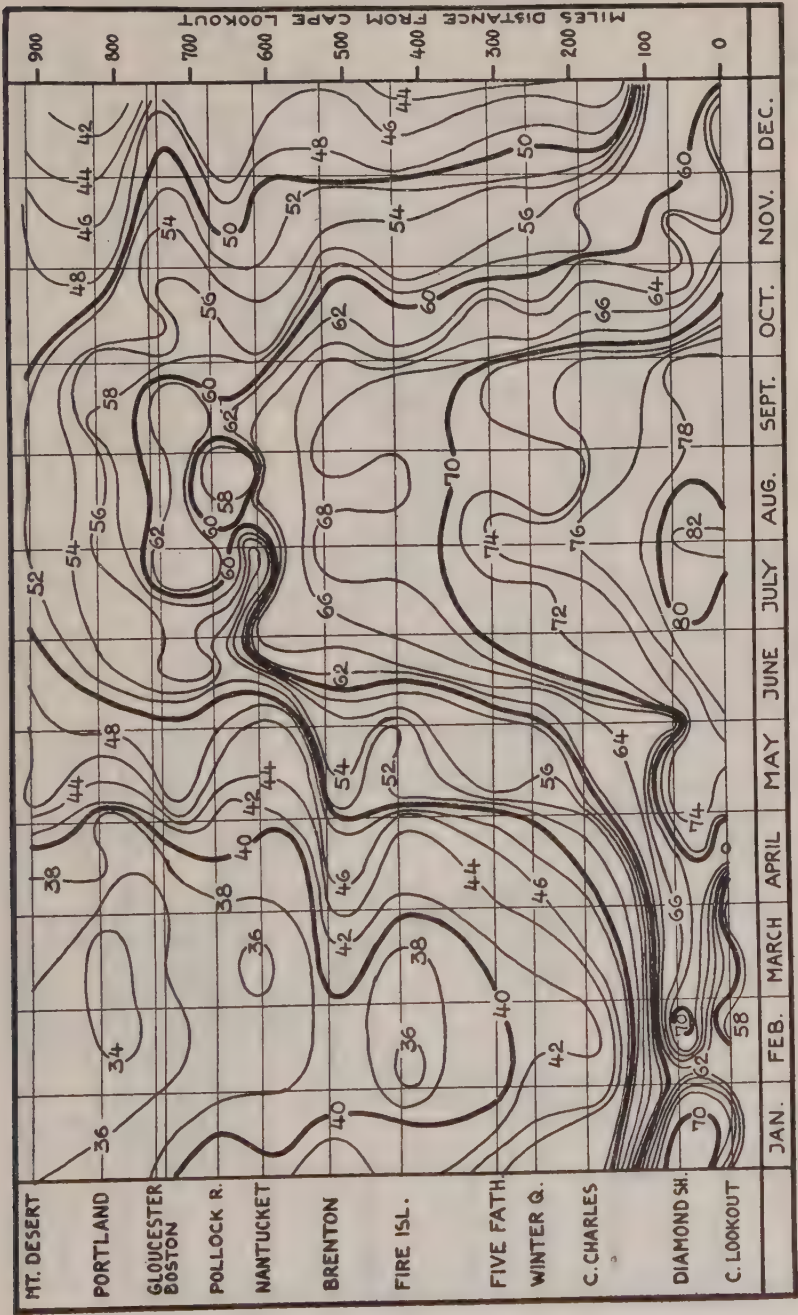


Fig. 10.—Seasonal course of isotherms for every 2 degrees F. during 1930, in shallow water along the Atlantic coast of the United States; plotted according to distances measured along the eight-fathom contour. Drawn to show conditions along the outside route in the Cape Cod region (SE of Nantucket Island). For conditions along the inside route by way of Nantucket Sound see figure 12. Positions of lightships and lighthouses on the left. Distances from Cape Lookout on the right.

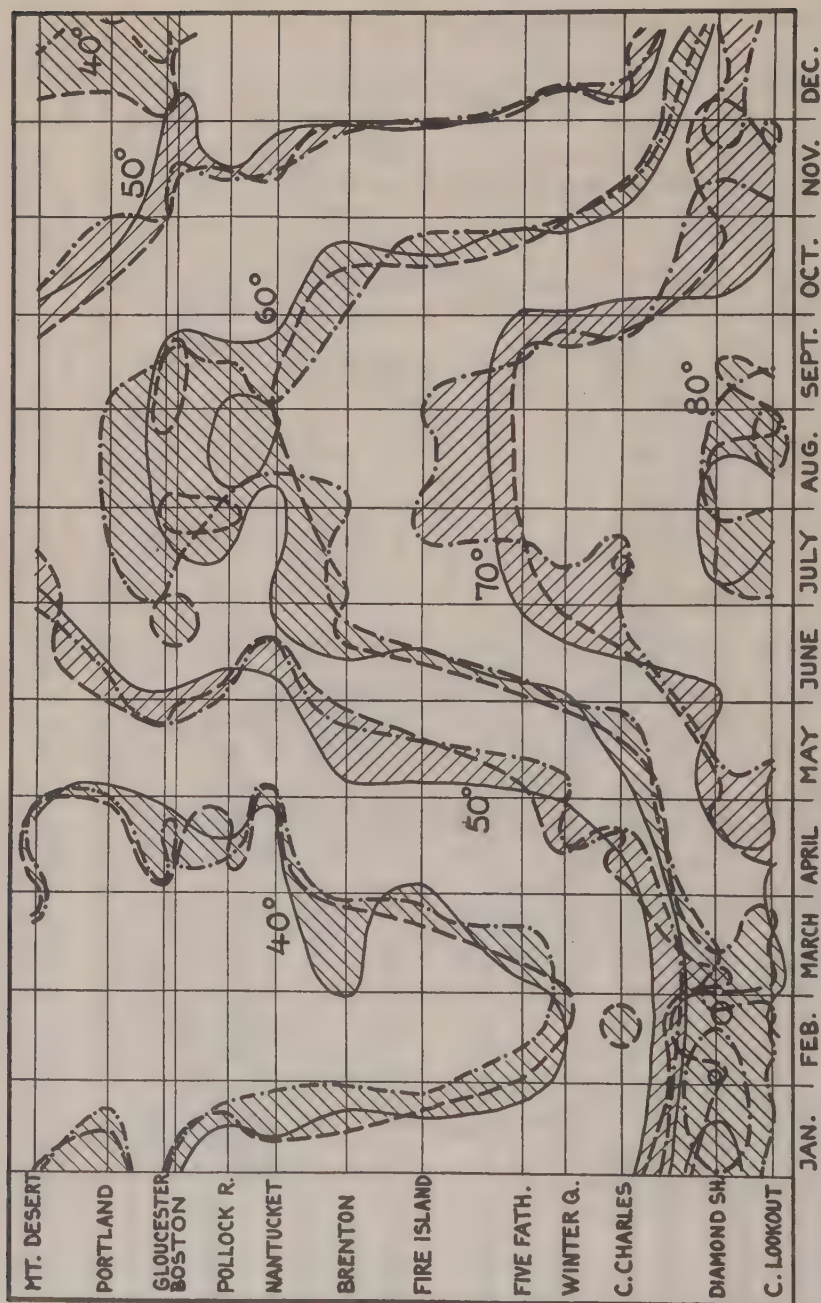


Fig. 11.—Seasonal course of isotherms for every 10 degrees F. during each of the years 1928-1930. Curves of the same temperature are connected by hatchings in alternate directions, showing the amount of annual variation.

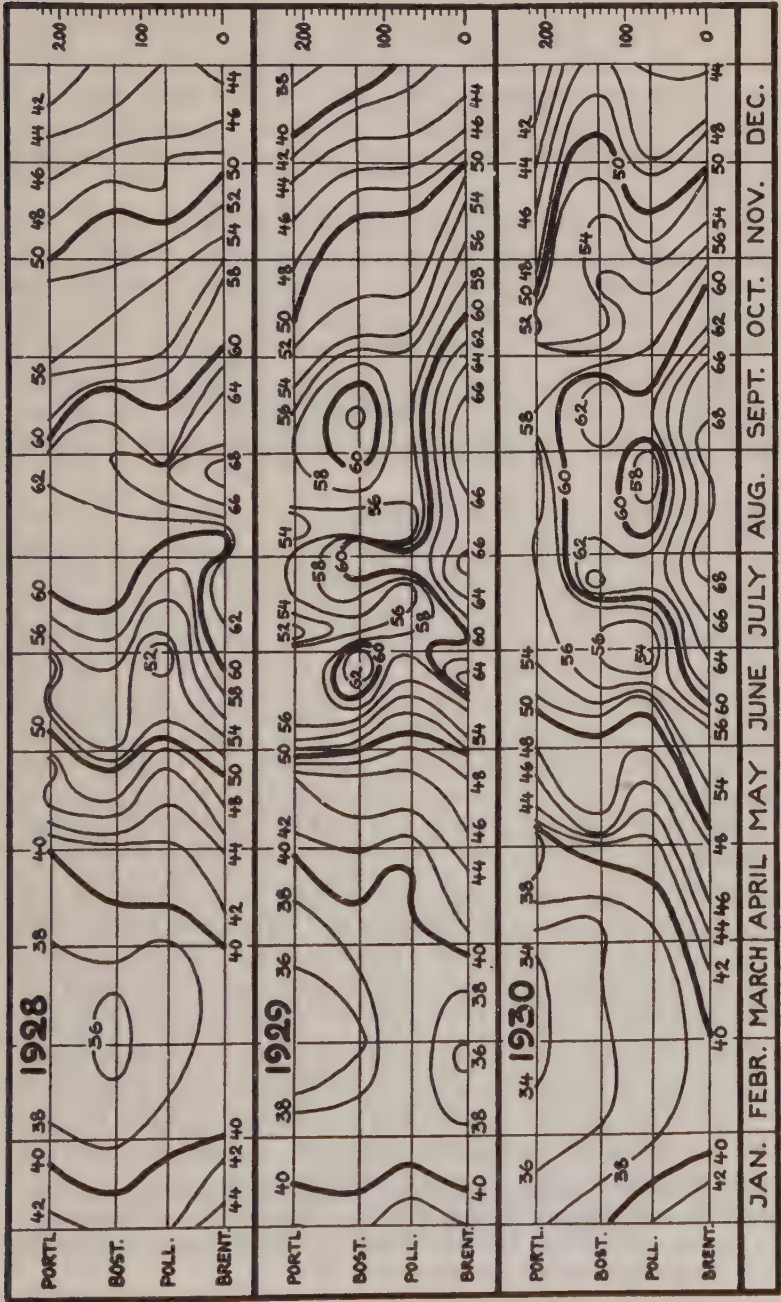


Fig. 12.—Temperature conditions during the years 1928–1930 along the inside route from the Middle Atlantic region to Massachusetts Bay and the Gulf of Maine, by way of Nantucket Sound, as shown by the temperature records from Brenton Reef, Pollock Rip, Boston and Portland Lightships. For comparison with figures 8–10. The temperature data from Gloucester harbor give too much distortion of a purely local nature to be worth including in these graphs. The vertical scale represents coastwise distances in miles from Brenton Reef.

therms in the Cape Hatteras region begin to loosen up and to disperse northward. This process of northward dispersal reaches its full force during the first part of May, and the months of May and June constitute the main period of readjustment of temperatures to the summer conditions which subsequently stabilize themselves along the coast line.

This period of temperature readjustment is characterized by the rapid northward regression of the isotherms, particularly within the range from 50 to 65 or 70 degrees F., from the region of Cape Hatteras to, or beyond, Cape Cod, and it is natural that this should be the period during which the summer-fish invade the Middle Atlantic fishing grounds from the south, while the winter-fish generally disappear to the northward with the regression of the lower isotherms from about 40 to about 50 degrees F., during March to the middle of May.

By the northward dispersal of the isotherms the apparent temperature barrier at Cape Hatteras has already been broken down completely by the end of May, and from the beginning of June on there is only a slow and gradual change in temperatures, but no temperature barrier of any sort, from the region south of Cape Hatteras to the region of Cape Cod. By the end of June, however, when more or less stable summer conditions have been developed, another temperature barrier has been formed in the region of Cape Cod or in the waters immediately to the southward and westward of this point. This temperature barrier generally centers around the isotherm of about 60 degrees F. and has a range of about 8 degrees F. altogether. It is generally found, however, that higher temperatures will also develop north of Cape Cod during the summer time, appearing particularly in the records from Boston Bay and from Gloucester. This occurrence is, in all probability, due to an increased effectiveness of the local heating, caused by the special topographic and dynamic features of this region, and at the height of the warm season (during the last half of August) it often appears that a temperature continuity at values as high as 60 degrees Fahrenheit or more may secondarily become established between the shallow-water areas on both sides of Cape Cod.²⁵ The Cape Cod region, however, undoubtedly still re-

²⁵ Figures 8-10 should be compared with figure 12 showing the temperature conditions along the inner passage through the Cape Cod-Nantucket Shoals region during the summer. For a more detailed discussion of the special problems of this area and its summer temperature barrier see page 26.

mains the needle's eye preventing most of the southern migrants from passing farther northward, as already well known to every student of the marine biology of these waters.

Towards the end of September the effects of autumnal cooling, or other factors tending to produce the conditions observed during the winter, begin to become noticeable, and during the month of October there is a very abrupt and rapid return of the isotherms from about 60 to about 70° F. towards Cape Hatteras, followed by a similar return of the isotherms between 50 and 60° F. during November and the first days of December, and by the 40 to 50° isotherms during December and January. These relationships are most clearly shown in fig. 11 on p. 42.

Thus the summer temperature barrier in the region of Cape Cod breaks down around the end of September, and the apparent²⁶ winter barrier at Cape Hatteras becomes reestablished during the first half of December.

Comparison with Rathbun's data for 1881-85.—The accompanying figure 14, with isotherms drawn for every five degrees Fahrenheit, shows the average pattern of the annual temperature cycle in the entire shallow-water zone from Tortugas to the Canadian boundary during the five-year period 1881-85 as presented by Rathbun (1887) in his ocean temperature chart No. 31.²⁷ It will appear from a comparison with figure 13 that Rathbun's data for 1881-85 give the same general picture of the annual temperature cycle *north* of Cape Hatteras as do the records from 1928-30, although it will be noticed that the vernal heating was generally relatively tardy getting under way during 1881-85 as shown by the fact that the 40° F. isotherm did not on the average recede to the northward of Five Fathom Bank Lightship²⁸ until the beginning of April (instead of the middle of March, see figure 13). Only in the data for 1882 (Rathbun 1887, Ocean Temperature Chart No. 27) do we find an agreement with conditions during 1928-30 in this respect. Once started, however, the

²⁶ See page 49.

²⁷ A comparison of Rathbun's chart with the one here rendered will serve to show both the similarities and the fundamental differences between the methods of presentation embodied in each (see p. 2).

²⁸ It is better to base our comparison on the records from this lightship than upon Winterquarter Shoals Lightship since the latter has changed its position considerably to the seaward between 1885 and 1928 (see p. 8) whereas Five-Fathom Bank Lightship remains in practically the same location as before.

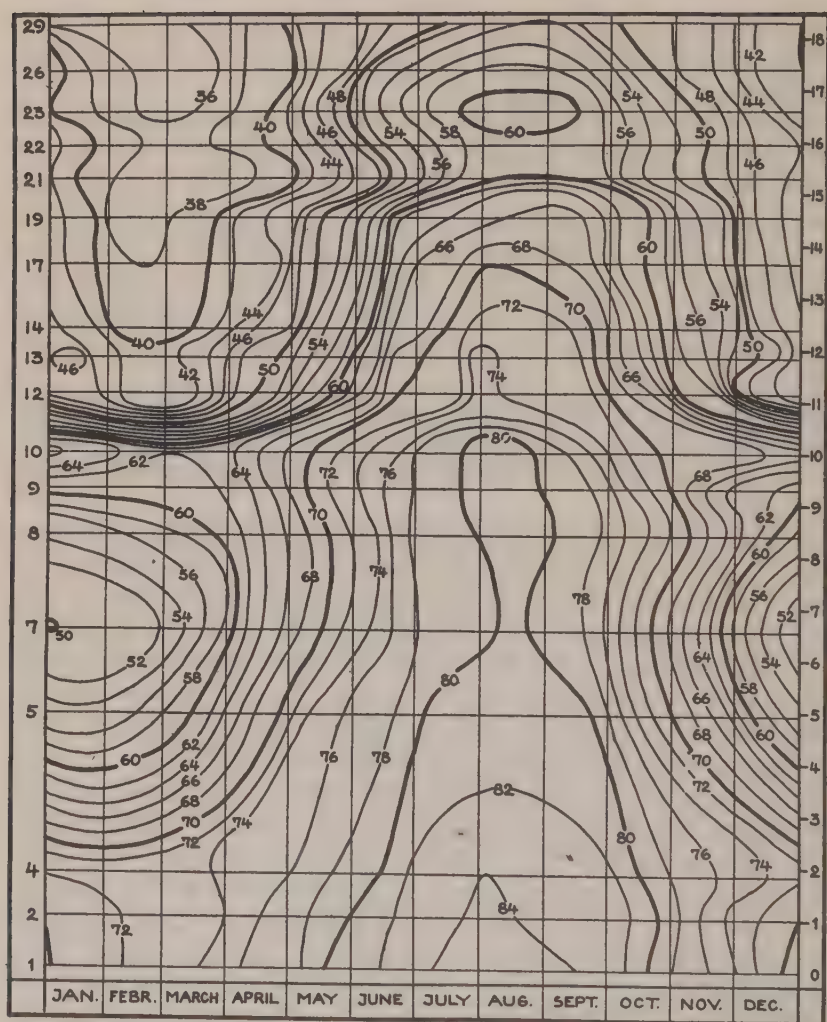


Fig. 13.—Average annual temperature cycle in shallow water from Dry Tortugas to Mt. Desert Rock. Isotherms for every 2 degrees Fahrenheit drawn according to the temperature records obtained during the period 1928–30. Lightships and lighthouses numbered (on the left) as in figure 1, on page 6. Coastwise distances from Dry Tortugas in hundreds of miles on the right.

vernal heating during 1881–85 apparently soon caught up with the pattern followed during 1928–30, and the northward movements of the isotherms from 50° to 70° F. are in very close agreement both in regard

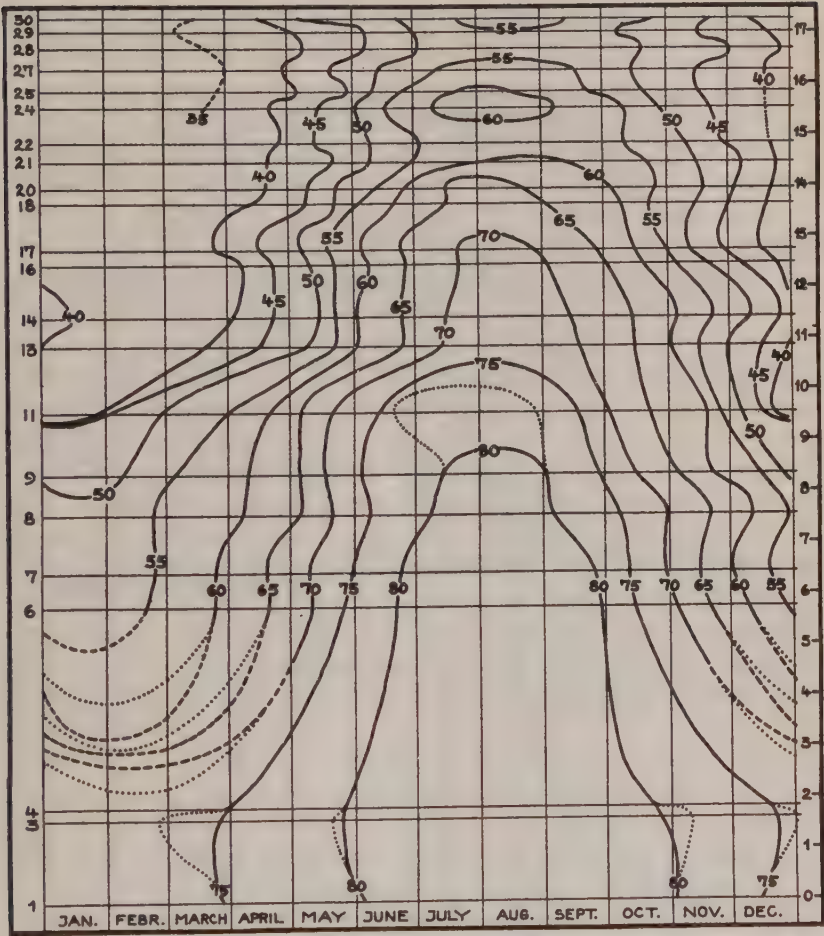


Fig. 14.—Average annual temperature cycle in shallow water from Tortugas to Petit Manan during the five-year period 1881-85. Modified from Rathbun (1887, *Ocean Temperature Chart No. 31*). Isotherms for every 5° F. Stations numbered as in figure 1. The deviations in the 75° and 80° isotherms at Carysfort Reef, and the appearance of temperatures as high as 80° F. or more at Bodies Island, are indicated by dotted lines, being regarded as phenomena of purely local significance only. A fragment of the 35° isotherm has been entered on the basis of Rathbun's annual curves for individual stations. For further explanations see the text.

to time and location during these two widely separated periods. A temperature barrier in the region of Cape Cod-Nantucket Shoals, generally ranging from around 55° to around 65° F., was established

in the summer also during the years 1881-85, and the southward movement of the isotherms in the fall, under the influence of autumnal

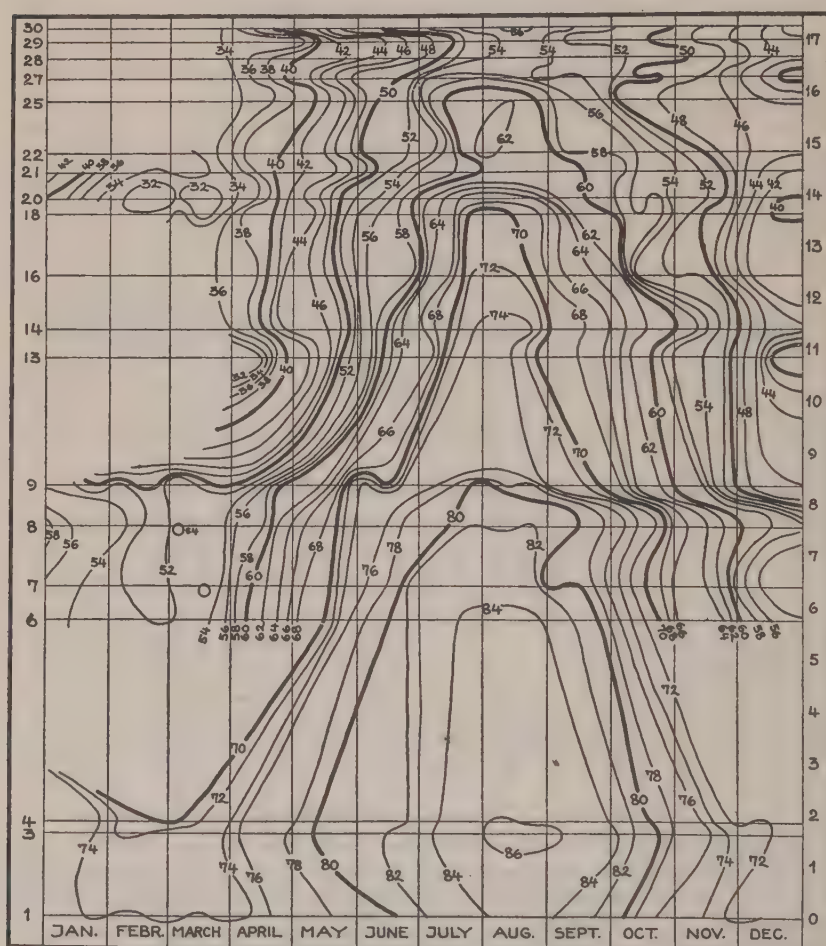


Fig. 15.—Temperature cycle in shallow water along the Atlantic Coast of the United States in the year 1885. Isotherms for every 2° F. drawn on the basis of the temperature curves for individual stations during that year rendered by Rathbun (1887, ocean temperature charts Nos. 1-25). Stations numbered as in figure 1.

cooling, is again in good general agreement for all stations north of Cape Hatteras during the two periods here compared. Figure 15,

with isotherms for every 2° F., showing the pattern of the shallow-water temperature cycle during 1885, has been prepared by the use of Rathbun's various temperature curves for each individual station during that year, and gives an illustration of a comparatively very late vernal heating north of Cape Hatteras, with the 40° F. isotherm about one month later at Five Fathom Bank lightship than during 1928-30. But even in this case the 50° F. isotherm is only about two weeks later than the average for 1928-30, and the higher isotherms run well within the ranges of variation for the latter period.

Since Rathbun's data from the Gulf of Maine include the records of several more stations²⁹ than those reporting from this region during 1928-30, figures 14 and 15 naturally shows the annual temperature history of that region in considerably greater detail than do figures 8-12.

It is of particular interest to notice from Rathbun's data that the area of relatively warm water (above 60° F.) north of Cape Cod during the summer is apparently not confined to Massachusetts Bay but usually extends northward at least as far as Boon Island. Another conspicuous feature of figures 14 and 15 is contributed by the early appearance and long duration of a relatively high summer temperature (55° F. or more) in the waters around Petit Manan, a feature attributed by Bigelow (1927, p. 575) to specially sheltered conditions in this location.

REGION OF CAPE HATTERAS.—In the immediately preceding paragraphs we have been able to show the existence of a very good general agreement between the pictures of the annual temperature cycle north of Cape Hatteras obtained from Rathbun's temperature curves and from the lighthouse and lightship temperature records for 1928-30. When we turn our attention to the region of Cape Hatteras itself, however, we find a very striking discordance between the indications given in Rathbun's temperature charts and the conditions suggested by the records from recent years. According to the latter, (see figure 13) the isotherms for 50° to 65° F. or even 70° F. would seem to converge and run closely together in the region of Cape Hatteras during the winter months, thus forming a very pronounced temperature barrier at this point during the cold season. In the

²⁹ Boon Island, Seguin, Mt. Desert Rock, Matinicus and Petit Manan, as compared with Portland Lightship and Mt. Desert Rock only. Rathbun did, on the other hand, not have any records from Massachusetts Bay, proper; only from Thatchers Island at Cape Ann.

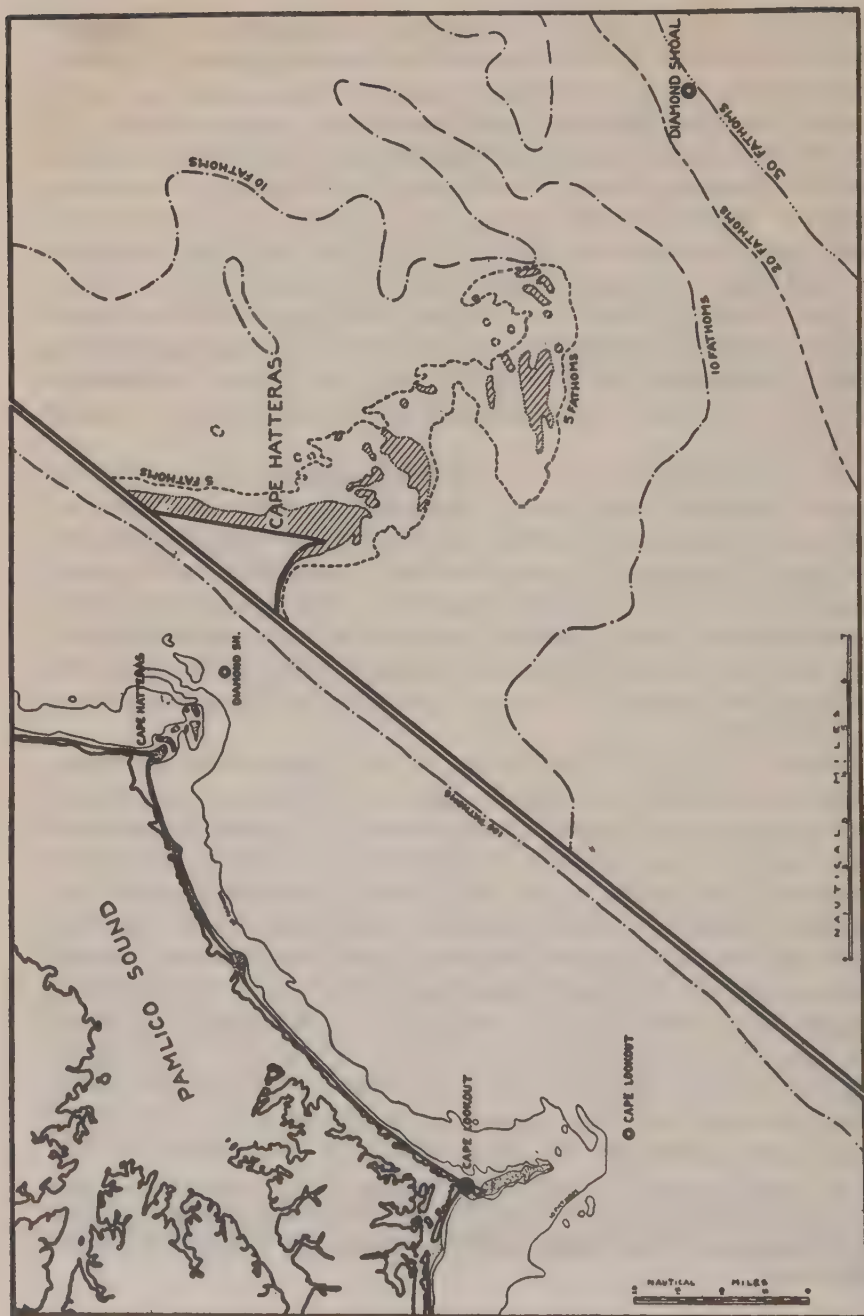


Fig. 16.—*Left:* Chart of the region from Cape Hatteras to Cape Lookout. *Right:* Large scale chart of the shoals between Cape Hatteras and Diamond Shoals Lightship.

graphs (figures 14 and 15) based upon Rathbun's temperature curves this phenomenon does, on the other hand, not appear at all, and there would seem to have been a continuity of ten-day average temperatures even as low as 50° F. around Cape Hatteras during 1881-85.

In Rathbun's data, however, the region of Cape Hatteras is only represented by interpolation between Cape Lookout Lighthouse (shore station) [9] and the stations north of Cape Hatteras. Of the latter, Bodie's Island, another shore station, shows such very great influences from purely local factors that it is questionable whether it can be considered fully comparable with the other localities off the open shore, and the next station to the northward, Winterquarter Lightship [13] is already 160 miles away from Cape Hatteras.³⁰ In the records from recent years the Cape Hatteras is represented by Diamond Shoals Lightship [10] directly off the Cape itself (about 13 miles southeast) and by Cape Lookout Lightship about 70 miles to the southwestward and about 20 miles Sx E $1\frac{1}{2}$ E from Cape Lookout Lighthouse, from which Rathbun obtained his records (see figure 16). It is therefore obvious that the discrepancy between figures 14 and 15 for 1881-85 and figure 13 for 1928-30 may, if not entirely, at least to a very considerable extent, be due to the fact that Rathbun's data are hardly adequate for an interpolation of conditions in the region of Cape Hatteras, such as has been rendered in these graphs; while a more complete and probably more correct picture is obtained from the records for 1928-30 as shown in figure 13. The writer sees no particular reason to doubt that a similar picture, with the same winter temperature barrier at Cape Hatteras, would also have been obtained for the years 1881-85 if temperature observations from the location of Diamond Shoals Lightship had been available at that time. Still the question remains as to the effectiveness of the temperature barrier at Cape Hatteras. Whether it extends all the way across the shallow-water zone or not. If not, whether it is supplemented by other factors tending to block the passage at this point, or whether it leaves an open path at relatively low temperatures through the waters closest to the shoreline, as might be indicated by the difference between the winter temperatures recorded from the lighthouse (1881-85) and from the lightship (1928-30) at Cape Lookout (figure 17).

As shown in this diagram the average surface temperatures at the

³⁰ Neither Diamond Shoal Lightship nor Chesapeake Lightship were included among the stations from which Rathbun obtained his data.

lighthouse and at the lightship are approximately the same during midsummer (June–September), but during the winter the average temperature at the shore station in the years 1881–85 sank to a minimum (in January), more than 10° F. below the average minimum (in February) at the lightship location (according to the records for 1928–30). In so far as these records are comparable, and we have no particular reason to suspect that they are not, it would, therefore, seem that a surface gradient with a range of about 10° F. can usually be expected to develop between the shoreline and Cape Lookout Lightship, about 18 miles off the point of the Cape.

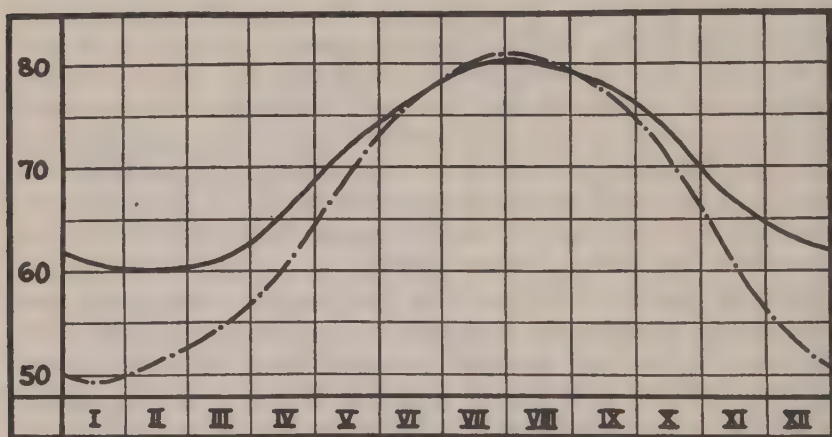


Fig. 17.—*Solid line*: average annual surface temperature curve at Cape Lookout Lightship during 1928–30, on the basis of 25-day periods. *Dots and dashes*: average annual surface temperature curve at Cape Lookout Lighthouse during 1881–85, on the basis of 10-day periods, calculated from Rathbun's temperature charts. *Vertical scale*: temperatures in degrees Fahrenheit.

Pursuing this comparison further, we also invariably find the more offshore station at Frying Pan Shoal showing a higher average mid-winter temperature (see figures 22 and 23) than any of the following stations situated farther to the southward (Rattlesnake Shoal, Charleston Lightship; Martin's Industry Lightship (1881–85); and St. Johns Lightship (1928–30)), the explanation being that these more southern stations are also closer to the shoreline and thus farther removed from the influence of the Gulf Stream to which the *higher* mid-winter temperatures at the more *northerly* and more offshore stations (Frying Pan Shoal, Cape Lookout Lightship and Diamond Shoal)

can undoubtedly be ascribed. On the basis of these comparisons, taking into consideration both Rathbun's data from 1881-85 as

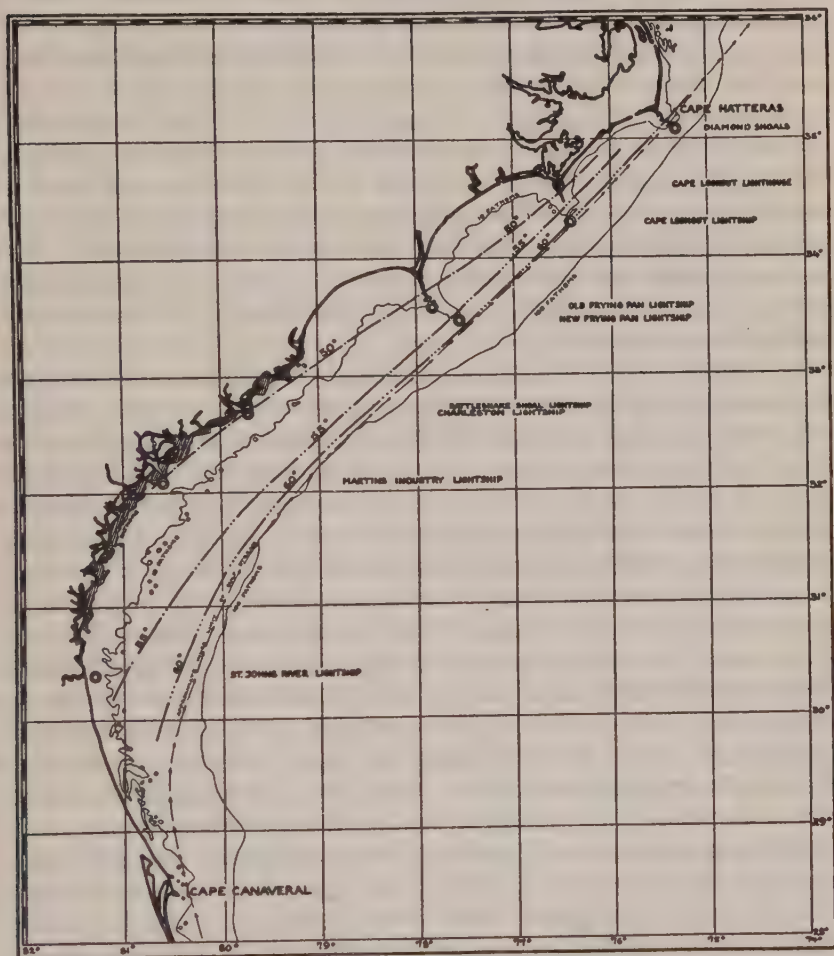


Fig. 18.—Average temperature distribution along the Atlantic Coast of the United States from Cape Hatteras southward, during period of minimum temperatures (January-February). Hatchings indicate depths less than 3 fathoms. 10-fathom and 100-fathom curves drawn in thin solid lines. Arrows indicate approximate inner limit of the Gulf Stream as shown in Chart No. 1001 published by the United States Coast and Geodetic Survey.

well as the records from recent years, figure 18 has been construed as an illustration of what must probably be the average

distribution of surface temperatures in the southern bight of the Atlantic coastline of the United States during the coldest period of the year (January–February). Where it comes within the points of observation (at Diamond Shoal and Cape Lookout Lightship) the 60° isotherm (or isocryme) apparently runs immediately outside (shoreward) of what has been determined by the United States Hydrographic Office as the approximate inner limit of the Gulf Stream, and it seems very reasonable to assume that this isotherm, and probably also the 55° isotherm at a somewhat greater distance, continues to run fairly parallel with this Gulf Stream boundary line right across the bight towards Cape Canaveral as indicated on the chart. It is at least certain that both isotherms on the average fall entirely outside of all our inshore stations from Charleston to St. Johns, inclusive, during the coldest period.

In consequence of the existence of these conditions south of Cape Hatteras during the winter, it becomes necessary for us to consider the possibility that a similar gradient, perpendicular upon the shoreline, might develop between Diamond Shoals Lightship and Cape Hatteras itself, and to discuss the significance which such a temperature gradient at this point might have for our biological considerations. It is clearly possible that the temperatures lower than 60° F. south of Cape Hatteras may be largely due to local cooling and do not necessarily imply any great transportation of cold water around the Cape. This possibility gains some confirmation from the very good general agreement between the air and surface temperature records for the stations from Cape Lookout Lighthouse to Martins Industry Lightship, particularly in the winter, during the years 1881–83, as shown in Rathbun's temperature charts. At Cape Lookout Lighthouse, the curves for the surface temperatures, which were taken above a depth of only one foot, "agree in nearly all their details with (the curves for) the air" (Rathbun 1887, p. 190). At Frying Pan, Rattlesnake, and Martins Industry Lightships the fluctuations in the surface temperatures are somewhat dampened in comparison with the fluctuation in the temperature of the air, but air and surface are in excellent agreement with each other in regard to the time and direction of all fluctuations, with coincident modes and depressions in their temperature curves throughout each winter period, as a glance at Rathbun's temperature charts No. 5–8 will show. On the basis of these findings it seems not only possible but also most probable that local cooling

must be the predominant factor in the production of the low winter temperatures along the coast south of Cape Hatteras, and it is not *a priori* necessary to assume that these low temperatures must be in continuity with the corresponding temperatures north of Cape Hatteras for the reason that their existence to the southward can only have been caused by an actual transportation of water at this temperature around the Cape from the north. There is, on the other hand, also the possibility to consider that equally low temperatures might develop along the shore by local cooling at Cape Hatteras itself. In the topographic and hydrographic conditions of this region, however, there are several very strong and very obvious arguments against the assumption that a similarly important surface temperature gradient as that between Cape Lookout and Cape Lookout Lightship might also develop between Cape Hatteras and Diamond Shoals Lightship. As shown in figure 16, an elevated ridge less than five fathoms deep extends outward nearly two-thirds of the way from Cape Hatteras to Diamond Shoals Lightship, with a complex group of shoals of even less than three fathoms depth reaching to within five miles from the lightship location. With a topography of this character, particularly in a prominent region such as that of Cape Hatteras, a very high degree of turbulence affecting the distribution and mixing of the water both in its horizontal and vertical aspect is plainly to be expected. From figure 18, we furthermore see that the approximate inner limit of the Gulf Stream, as determined by the United States Coast and Geodetic Survey, cuts across the outer edge of the shoals less than three fathoms deep off Cape Hatteras, and it therefore seems fairly certain that at least the marginal warm waters of the Gulf Stream will commonly, to a greater or less extent, be drawn into the turbulent mixing over these shoals. While it is probable that the average inshore surface temperatures at Cape Hatteras in midwinter may be somewhat lower than the average surface temperatures at Diamond Shoals Lightship, it is therefore, on the other hand, very improbable that the difference at this point should be nearly as great as in the waters to the southwestward, and it is clear that the inshore belt of lower temperatures, such as they may be, must under any circumstance be greatly restricted in its width in the region of the shoals off Cape Hatteras. It may finally also be pointed out that the migratory possibilities offered by such low temperatures as might occur at times in this area would be greatly detracted from by its topo-

graphical and dynamic obstacles in the form of its very shallow depth and violent surf action (breakers and rips). Only on the occasions when the cold water reaches out beyond the shoals towards the lightship location would a really good opportunity for passage at low temperatures be afforded, but such conditions are too rare³¹ and of too short duration to be of any great significance for our biological considerations.

For these various reasons the author feels fairly confident that the midwinter temperatures below 60° F. developing to the southwestward of Cape Hatteras are not in effective continuity with the same temperatures to the northward of the Cape; that is, that the chance of a continuous coastwise passage from the Middle Atlantic region into the southern region, and vice versa, at these low temperatures is so greatly reduced as to become practically negligible through the conditions obtaining in the region of Cape Hatteras. The version of the annual temperature cycle and the temperature relationship between the South and Middle Atlantic regions rendered on the basis of observations from 1928-30, in figures 8-13, showing a well-developed winter temperature barrier at Cape Hatteras, is, therefore, probably more complete and more correct in its biological implications than is the version obtained from Rathbun's data (figures 14 and 15) which are inadequate to show the separation of the southern waters from the northern during midwinter. Perhaps the clearest and most complete picture may be obtained by a combination of Rathbun's data with the more recent observations at Diamond Shoals Lightship, as shown in figure 19. In this picture not even the 60° isotherm is continuous around Cape Hatteras. It is probable, however, that observations nearer to the Cape itself might establish a narrow continuity also at this temperature but hardly in any significant manner at values lower than 60°.

SOUTHERN ATLANTIC REGION AND THE STRAITS OF FLORIDA.—Our consideration of temperature conditions in the coastal waters between Cape Hatteras and the Straits of Florida suffers from the incompleteness of our records from the southern half of this area. In Rathbun's data there is a hiatus of 390 miles between Fowey Rocks lighthouse, the northernmost point of observation in the straits of Florida, and Martins Industry Lightship, the southernmost station along the open Atlantic coast. While the subsequent

³¹ So far as temperatures below 60° F. are concerned.

addition of St. Johns Lightship constitutes a considerable improvement and southward extension of the series of stations north of the gap, it still leaves a stretch of 305 miles of coastal water unaccounted for also in the records for 1928-30. This hiatus in our observations is particularly unfortunate for our consideration of the distribution of shallow-water temperatures during the winter, since it covers an average temperature range of about 18° F. during the coldest period of the year, leaving the details of the coastwise gradient from about 55° F. to about 73° F. purely a matter of conjecture, entirely unaccounted for by actual observations. During the warm season the temperature range of the unobserved stretch becomes reduced to an average minimum of only about 3° F. in July to September, and from May to October, inclusive, the hiatus can hardly be said to be of any significance at all for our investigation.

From figures 13 and 14 it will be seen that the 60° isotherm may as a rule be expected to invade the coastal waters south of Cape Hatteras towards the end of November and to remain in the south until the first half of April. During December a temperature of 55° F., or less, will apparently develop independently (see p. 54) south of Cape Hatteras, to disappear again from this region under the influence of vernal heating already around the beginning of March. In January and February the coastal waters in the northern part of the southern Atlantic region will even reach a temperature as low as about 50° F. in the area nearest to the shoreline (p. 52),³² as shown by Rathbun's data from Cape Lookout Lighthouse (see figure 23) and by the recent records from Charleston Lightship (figure 22).

Figure 18, which has already been sufficiently explained on page 53, shows the distribution of surface isotherms believed to be normal for the southern Atlantic region during the coldest part of the year. If the interpretation of the data upon which this chart is based is correct, it is clear that neither the Frying Pan Shoals observations nor the Cape Lookout Lightship records will give any true picture of temperature conditions in the shallow-water zone proper, except in so far as the outer fringe of this zone at the prominent, but isolated, projections of Cape

³² According to thermograph records kindly made available by Dr. Prytherch, Director of the Fisheries Biological Station at Beaufort, N. C., the sea water temperatures in this inland locality (situated opposite the entrance shown in the left half of Figure 16 about 9 miles west of Cape Lookout) were both in January and again in December, 1930 below 45° F. even in the five-day averages.

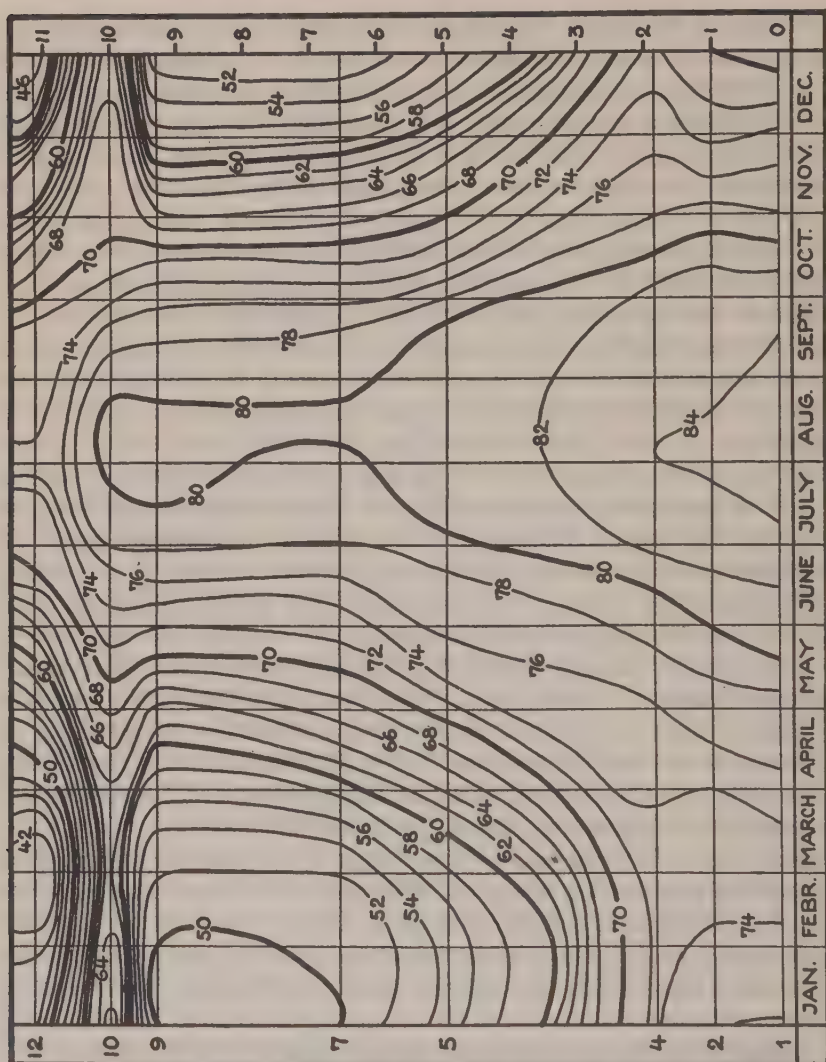


Fig. 19.—Picture of the annual temperature cycle in shallow water in the Southern Section of the Atlantic Coast of the United States, as obtained by combining the average records for the period 1928-30 from Dry Tortugas (1), Sombroero Key (2), Fowey Rocks (4), St. Johns (5), Charleston (7), Diamond Shoal (10) and Cape Charles (12) for the years 1881-85 from Cape Lookout Lighthouse (Rathbun) (9), disregarding the 1928-30 records from the offshore stations of Cape Lookout, Lightskip and Frying Pan Lightship. Coastwise distances from Dry Tortugas in hundreds of miles on the right.

Fear and Cape Lookout are concerned, and even at these two points the observations from the lightships' will not be representative of the temperature continuity in the waters closer to the shoreline, as clearly shown by Rathbun's data from Cape Lookout Lighthouse (see page 51). To obtain a picture which will probably be more truly representative of the entire shallow-water zone proper south of Cape Hatteras, with consideration of the continuities established in the inner parts of this zone at the constrictions of Cape Fear and Cape Lookout, the accompanying figure 19 has been prepared by the omission of the records from Frying Pan and Cape Lookout Lightships, as being irrelevant to the continuities here concerned, and by the combination of Rathbun's data with the recent records from other localities. In this figure we see the winter temperature barrier at Cape Hatteras take on a much sharper character than in figure 13, the difference being due to the change in the picture of its southern aspect. We also find a much greater geographical extension of the low-temperature area of the shallow-water zone south of Cape Hatteras indicated in figure 19, in accordance with our considerations in the preceding. The perfect sequence in the appearance of the isotherms in the averages for St. Johns (5) and Charleston (7) lightships during the period 1928-30 and in the averages for Cape Lookout Lighthouse (9) during the period 1881-85 may be considered to confirm the justification of combining these records in the chosen manner. The question of the completeness and efficacy of the temperature barrier at Cape Hatteras has already been discussed on page 54. While observations closer to the shore of the Cape itself might show a temperature continuity through this region at a somewhat lower level than indicated in figure 19 (64° F.), the writer feels confident that the colder areas to the southward and to the northward must be separated from each other during the winter by a biologically quite efficient barrier of higher temperatures coupled with mechanical and dynamical obstacles in the region of Cape Hatteras.

On the basis of the preceding considerations, we may now be said to have gained a rough, but fairly complete, picture of winter conditions as far south as St. Johns Lightship, but in the 305-mile hiatus between this station and Fowey Rocks Lighthouse in the Straits of Florida, the course of the isotherms from 55° to 73° F. is completely lost track of so far as actual observations are concerned. From the beginning of November to the end of December these isotherms appear

from the north and disappear again to the southward at St. Johns Lightship. During February, March and April they are again encountered in this location on their northward course. In the meantime, however, none of these isotherms from 55° to 73° F. will, on the average, be found to have reached as far south as Fowey Rocks, and we are therefore unable to determine from actual observations even their approximate distribution from the time of their disappearance from St. Johns Lightship in the late fall until they again reappear in that locality on their northward course in the spring. From a consideration of the situation north and south of the unknown stretch, we may, however, nevertheless be able to discern certain possibilities in regard to the most probable mid-winter distribution of the 55° to 73° isotherms.

As we have already seen in the preceding (page 52), the mid-winter temperatures of 60° F. or higher at Cape Hatteras and at Cape Lookout lightships seem rather definitely associated with the proximity of these locations to the inner edge of the Gulf Stream, while much lower temperatures are found in the southern Atlantic bight of the United States coastline farther away from the Gulf Stream, but also farther to the southward (page 52). If this relationship is continued into the area between St. Johns Lightship and Fowey Rocks, we should expect the isotherms for 60° F. and for higher temperatures to remain offshore, while the lower temperatures extend fairly uniformly along the shallow-water zone, until the shoreline again approaches the Gulf Stream in the region of Cape Canaveral (see figure 18 on page 53). From St. Johns to the neighborhood of Cape Canaveral we would then only find a very slow and gradual increase in the coastal shallow-water temperature, followed, in the latter vicinity, or perhaps rather in the region between Cape Canaveral and Jupiter Inlet, Fla., by a comparatively sudden rise from about 60° to over 70° F., forming a second winter barrier similar in its northern approach³³ to that simultaneously formed at Cape Hatteras at a lower temperature level (50° to 60° F.). In figure 19 the mid-winter distribution of the isotherms has been drawn in accordance with this assumption of a relatively steep gradient from 60° to 70° F. between Cape Canaveral

³³ The geographical surface temperature gradient in this southern region had perhaps better been designated as a warm front than as a temperature barrier since it would not separate from each other two areas of similar temperature as does the winter barrier at Cape Hatteras.

and Jupiter Inlet, Fla. It seems quite possible that this rise in temperature may actually take place over a much shorter distance in the immediate vicinity of Cape Canaveral, but it is, on the other hand, also possible that it may extend over a wider range. A relative concentration of mid-winter isotherms somewhere in the region here indicated does, in any event, seem much more probable than the assumption of an even rise in temperature from St. Johns Lightship to Fowey Rocks, as shown for comparison in figure 13 on page 46.

During the summer the temperatures in the southern section of the shallow-water zone along the Atlantic coast of the United States are practically uniform with the temperatures in the Straits of Florida, the difference in temperature between Fowey Rocks and Cape Look-out, about 750 miles apart, being on an average less than 8° F. from the beginning of May to the middle of October, and only about 4° F. from July to September, inclusive.

In the Straits of Florida we encounter shallow-water temperature conditions of a tropical nature, and we here enter a region which has its southern limit probably somewhere along the coast of Brazil, and which is therefore largely beyond the scope of the present report. The temperature relationship of the Straits of Florida to the coastal waters to the northward has been sufficiently discussed in the preceding paragraphs.

SUMMARY OF ANNUAL GEOGRAPHIC TEMPERATURE CYCLE.—In the shallow waters along the Atlantic coast of the United States we thus have seasonal temperature barriers established at Cape Hatteras during the winter and in the neighborhood of Cape Cod during the summer, but the impression often given, that there should be a set of more or less permanent temperature barriers at these two points, is entirely erroneous and contrary to the facts. In the winter there is a free access for all the migratory cold water forms to penetrate as far south as to the neighborhood of Cape Hatteras, and in the summer the southern forms may move as far north as Cape Cod encountering only a slow and gradual decline in temperature on the way. The discoveries of the extent of the southward penetration of the northern species during the winter, which have surprised the investigators during the last few years, are therefore only what one should have been entirely ready to expect had these temperature relationships been worked out beforehand. The northward penetration of the southern forms to Cape Cod, but generally

not farther, is also in full accordance with our findings concerning the distribution of shallow water temperatures during the warm season, as already well known in a general way.

In the conclusions set forth in the preceding paragraph is also implied that it would be difficult for either the northern or the southern faunistic elements to contribute any permanent residents to the region between Cape Hatteras and Cape Cod, and the scarcity or almost complete absence of any all-year-round residents among the fishes of the Middle Atlantic coast is one of the outstanding features in the zoogeography of this region.

It is also suggested that the transition from the midwinter temperature conditions in the southern section of the Atlantic coastal waters of the United States to the midwinter temperatures of the Straits of Florida may take the form of a relatively abrupt warm front somewhere in the neighborhood of the region between Jupiter Inlet and Cape Canaveral, Florida, rather than the form of a gradual and equally distributed increase in temperature. On the basis of this assumption we should, therefore, expect to find a critical and perhaps limiting point for the winter migrations of subtropical species in the vicinity of Cape Canaveral. During the summer the temperatures in the Straits of Florida are uniform with the shallow water temperatures to the northward as far as the region of Cape Hatteras, from which point a gradual change begins to become noticeable. Although no abrupt temperature barrier is to be found at Cape Hatteras during the summer time, it is, therefore, nevertheless to be expected that this point will form the northern limit of distribution for the stenothermal tropical forms during the warm season.

In the Straits of Florida we find the northern boundary of the Tropical American Seas with a winter temperature above 70° F. in which the stenothermal tropical forms may remain all year around.

FLUCTUATIONS IN THE GEOGRAPHICAL EXTENSION OF THE VARIOUS TEMPERATURE INTERVALS

It might, in connection with the preceding discussion, be of interest to determine the variations in the length of the section of the shallow water belt which is covered by the geographical range of any given temperature interval at various times of the year. For this purpose the accompanying fig. 20 has been prepared, showing the fluctuations in the distances between every 10° isotherm in the Middle Atlantic

Region and the Gulf of Maine during the year 1929³⁴ measured along the eight fathom contour. It will be seen, from this figure, that the stretch of coastal water occupied by the temperature interval from 40 to 50° F., starting with a length of about 600 miles in the beginning of January, has shrunk to only about 120 miles during the last part of February, to increase again to nearly 600 miles towards the middle of May. After the middle of May the 40° isotherm disappears from our records, receding northward beyond the bounds of our observations, and we are therefore unable to follow the further history of this temperature interval until it again comes entirely within the range of our observations for a brief period during the last part of December. For similar reasons the width of the 50 to 60° interval cannot be determined from the last part of July to the early part of October, and the widths of the 60 to 70° and the 70 to 80° intervals can only be recorded for longer or shorter periods during the summer.

It would appear that each temperature interval reaches its maximum geographical extension towards the end of the period of its presence within the area here considered,³⁵ the reason for this being that the higher isotherms will start receding to the southward before the lower ones have yet been affected to the same extent by the approach of winter, so that there will be a temporary expansion of the distance between the higher and the lower temperature points, before the location of the latter comes fully under the influence of the autumnal factors, whether they be of a dynamic character or simply in the nature of a direct cooling. For the same reason, it will also be seen that the lower temperature intervals reach their maximum extensions successively later in the fall and winter, according to their positions on the temperature scale.

In their ecological implications these conclusions obviously mean that, whereas the biological processes of the shallow water zone dependent, for instance, upon temperatures between 40 and 50° F.,

³⁴ Conditions in the other years from which we have adequate information available are in good general agreement with those observed in 1929, with the exception that the establishment of a direct continuity between the 60° isotherms north and south of Cape Cod during the month of August in the years 1928 and 1930 causes the range of the 60 to 70° temperature interval to become much greater at these times than at any time during 1929.

³⁵ Due to the uncertainty about the exact distribution of winter temperatures south of Cape Hatteras (see page 59) these considerations can not be extended to include also the southern section of the Atlantic coastal waters of the United States.

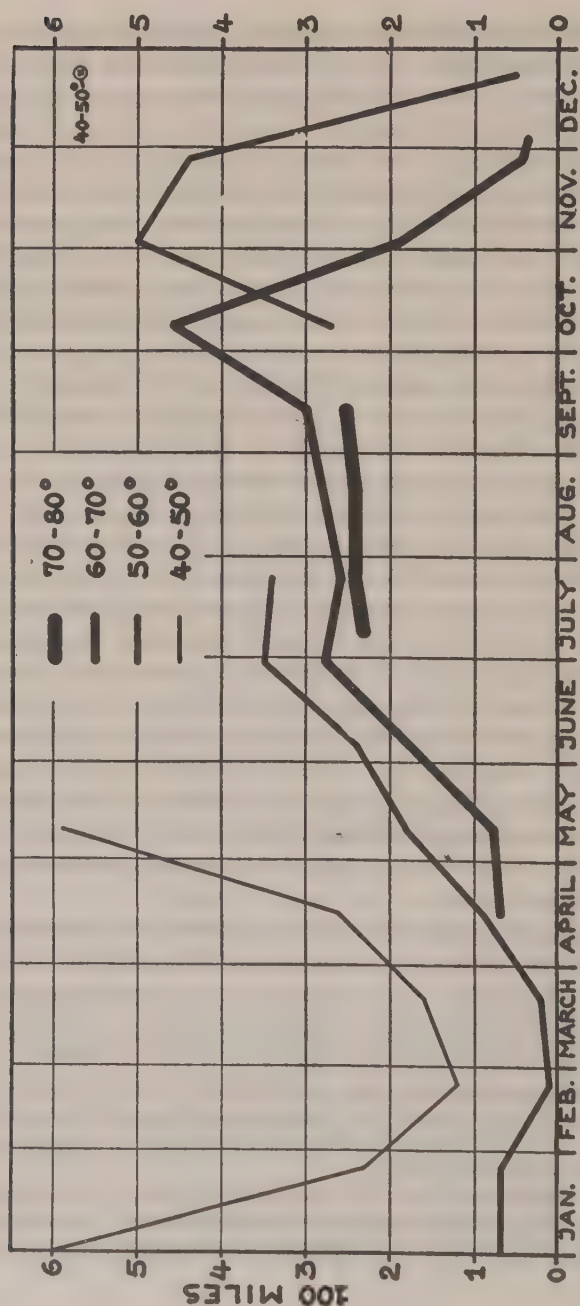


Fig. 20.—Seasonal fluctuations in the length of the temperature sections of the shallow-water zone for each ten degree temperature interval. Further explanations in the text.

in the beginning of January can have free play over a stretch of about 600 miles of coastal waters, they will during the last part of February, of necessity be limited to only a range of about 120 miles, to spread out again gradually during the following months, etc. At the moment of this writing the author is not aware of any particular set of zoogeographic facts to which these considerations, can at once be applied, but they represent a method of approach which might recommend itself for future use particularly in the study of problems involving an inclusive consideration of the total amount of biological processes or activities of various kinds, such as for instance spawning, within the entire geographical range of a species.

ANNUAL TEMPERATURE RANGE IN DIFFERENT SECTIONS OF THE SHALLOW WATER ZONE

It will have appeared, from our discussion of seasonal changes in space and time, that the area of the Eastern Coast of the United States covered by our records is naturally divided into at least six different sections which are distinct from each other in regard to their annual temperature history. These sections are: 1) The Straits of Florida, probably fairly sharply limited from the Southern Atlantic region during the winter by a relatively abrupt transition (warm front) in the region of Cape Canaveral. 2) The Southern Atlantic region between Cape Canaveral and Cape Hatteras, with summer temperatures uniform with those of the Straits of Florida and winter temperatures approaching or similar to those of the Middle Atlantic region, but separated from the latter by the temperature barrier at Cape Hatteras. 3) The region of Cape Hatteras, represented by the Diamond Shoals and Cape Lookout Lightships, with a winter temperature barrier which breaks down entirely during the warm season. 4) The region of the Middle Atlantic coast between Cape Hatteras and Cape Cod, through which the isotherms move rapidly in long sweeps between the winter barrier at Cape Hatteras and the summer barrier at Cape Cod, but which, within its own boundaries, does not contain any temperature barrier at any time of the year. This region includes all the lightships and lighthouses from Cape Charles to Brenton Reef. (5) The region of Cape Cod, represented by the Nantucket and the Pollock Rip Lightships, with a moderate temperature barrier in the summer, which completely disappears during the winter. (6) The region of the Gulf of Maine, with comparatively moderate

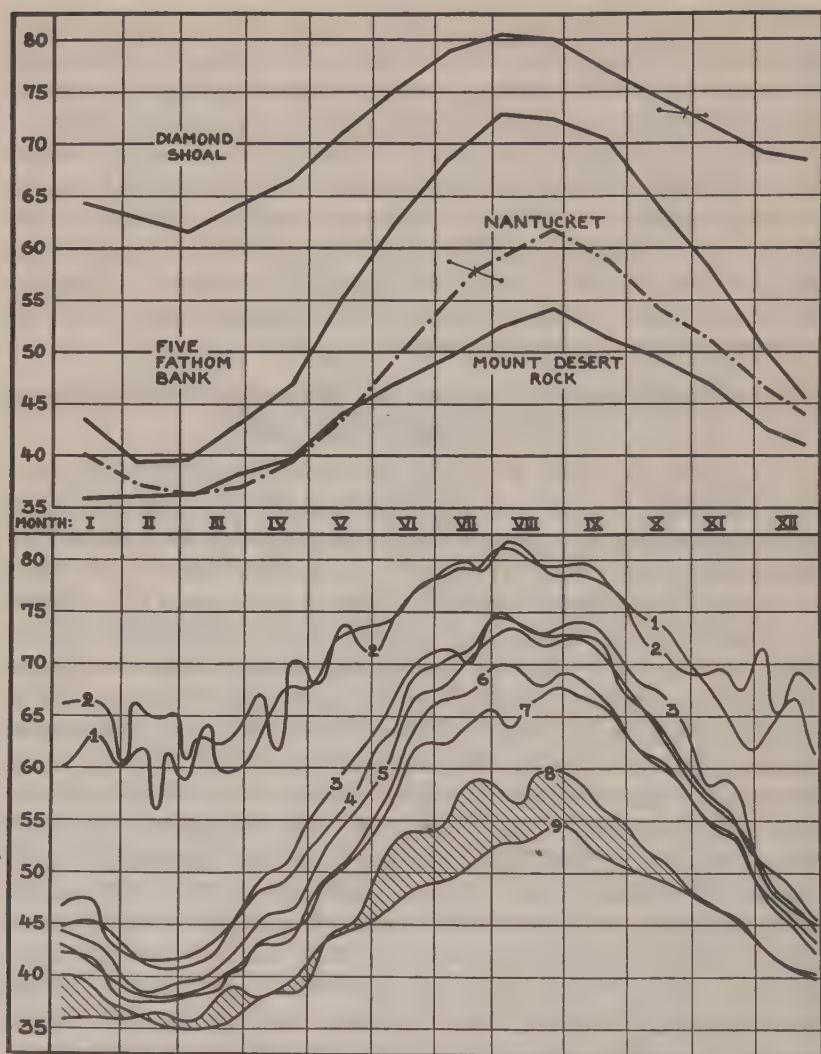


Fig. 21.—Above: Average annual temperature curves at four representative lightships, one for each of the four thermographic regions in the shallow-water zone from Cape Hatteras to the Gulf of Maine, plotted on the basis of 25-day periods for the three years 1928–1930.* Below: Average annual curves drawn separately, on a basis of five-day periods, from the three-year records of the two lightships in the region of Cape Hatteras (1. Cape Lookout. 2.

* Only for the two years 1928–29 in the case of the Diamond Shoal Lightship, as the 1930 records from this locality were not yet available when this illustration was prepared.

temperatures all year round, and without any temperature barrier at any time of the year within the limits of our recorded observations.

It is quite obvious from our figures 13-15 (pp. 46-48) that these six regions must differ quite fundamentally from each other in regard to the nature of their annual temperature curves, and this fact is still more clearly shown in the accompanying figures 21-23. Figure 23 shows the average annual surface temperature curves in different localities during the five-year period 1881-85, as calculated from Rathbun's temperature charts on the basis of ten-day periods. Figures 21 and 22 give similar information for various stations during 1928-30.

Starting from the southern end of the coastal shallow water belt with which we are here concerned, we first encounter, in the Straits of Florida, a region of uniformly high average temperatures with a seasonal range of variations of only 10°-12° F., from around 73° to around 85° or 86° F. (figs. 22 and 23). In the section from Cape Canaveral to Cape Hatteras we next encounter a region in which high summer temperatures, about equal to those in the Straits of Florida, alternate with relatively low winter temperatures, giving a seasonal range of variations of about 30°-35° F., from about 50°-55° F. to about 80°-85° F. (figs. 22 and 23). In the boundary region of Cape Hatteras comparatively uniform and relatively high temperatures again prevail (fig. 22), with an average annual range for 25-day periods of only about 20° F. or less, from a little over 60° F. to a little over 80° F., although the extreme range when shorter periods are considered may exceed 25° or even 30° F. due to the violent fluctuations in the temperatures in this area during the cold season. At this point, however, we are only considering the seasonal trends of the temperature curves, not their extreme variations which will be taken up for discussion later (p. 75). In the Middle Atlantic region we find a repetition of conditions south of Cape Hatteras at a somewhat

Diamond Shoal); of the five lightships along the Middle Atlantic coast (3. Cape Charles. 4. Winter Quarter. 5. Five-Fathom Bank. 6. Fire Island. 7. Brenton Reef); and of the two typical stations in the Gulf of Maine (8. Portland. 9. Mt. Desert Rock, connected by oblique hatchings). The records for the two lightships in the Cape Cod region (Nantucket and Pollock Rip) and for Boston Bay and Gloucester have been omitted to avoid unnecessary confusion.*

* The Cape Cod region shows intermediate temperatures between those of the Middle Atlantic coast and those of the Gulf of Maine. The curves for Boston Bay and Gloucester show distortions probably due to strictly local heating and cooling and can therefore not be considered entirely significant for our considerations at this point, in so far as their finer details are concerned.

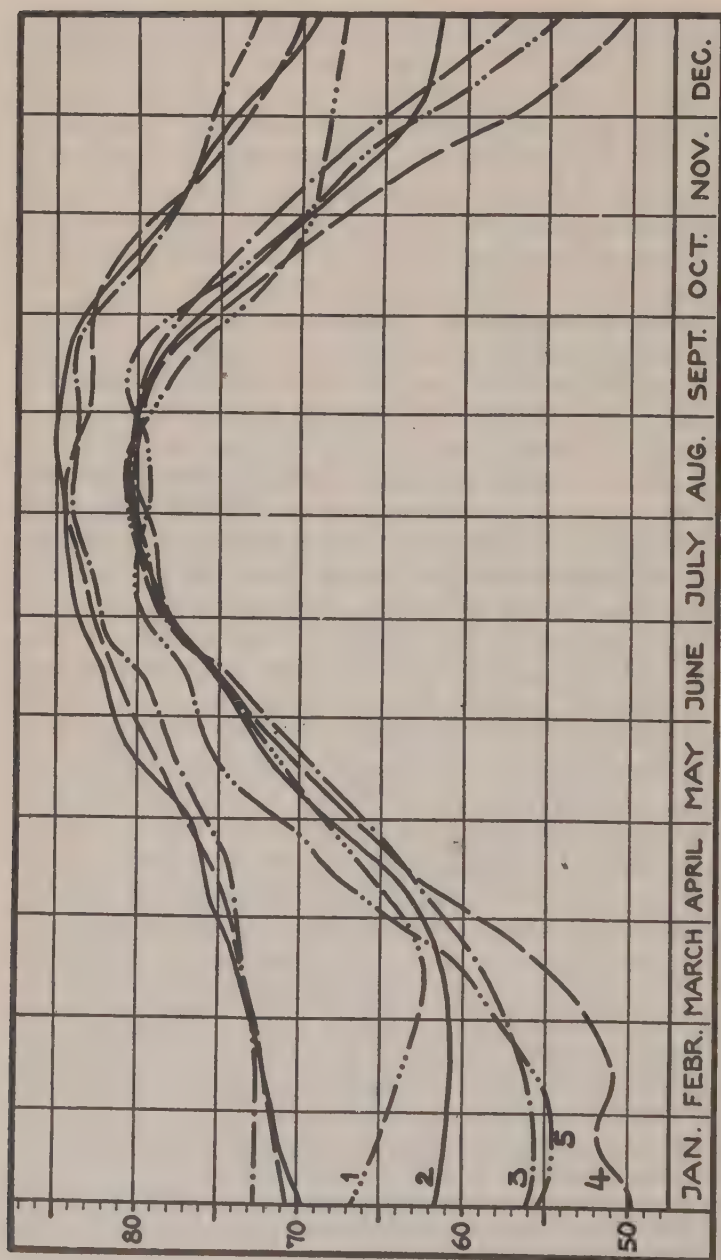


Fig. 22.—Average annual temperature curves for the stations in the Southern Atlantic region and in the Straits of Florida, during 1928-30. Upper group (Straits of Florida): solid line (—): Dry Tortugas. Broken line (---): Sombrovo Key. Dots and dashes (·-·-·): Fowey Rocks. Lower group (Atlantic Coast): (1), three dots, two dashes (·-·-·-·-): Diamond Shoal. (2), solid line (—): Cape Lookout Lightship. (3), dot and dash (-·-·-): Frying Pan Shoal. (4), broken line (- - -): Charleston Lightship. (5), dash and two dots (-·-·-): St. Johns. Temperature scale in degrees Fahrenheit on the left.

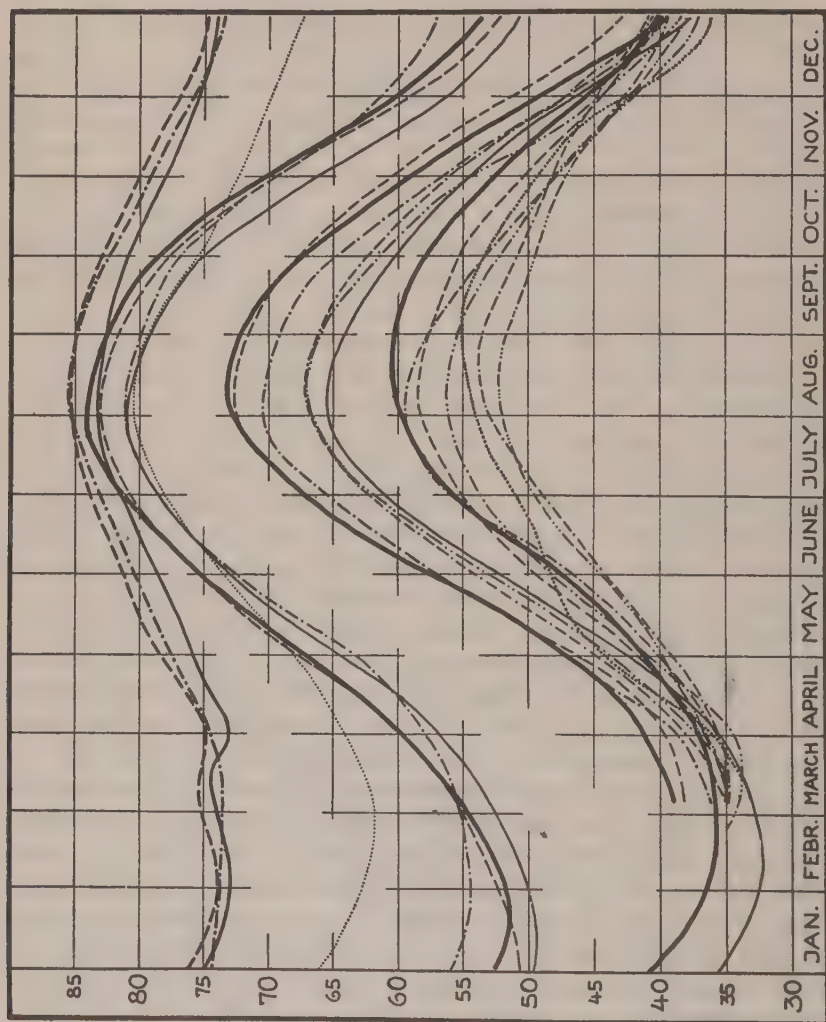
lower temperature level, with an annual range of about 30°–35° F., from about 35°–40° F. in the winter to 65°–75° F. in the summer (figs. 21 and 23). In the region of Cape Cod-Nantucket Shoals, there is a fairly abrupt drop in the summer temperature averages, reducing them to a maximum of less than 65° F. for 25-day periods (actually not over 62° F. during the years 1881–85, and 1928–30) thereby also reducing the seasonal range of variations to only about 25° F. or less.³⁶ North of Cape Cod the maximum summer temperature gradually decreases³⁷ until it becomes less than 55° at Mt. Desert Rock (figs. 21 and 23) with a seasonal range of less than 20° F.

We thus have three areas of comparatively uniform temperatures throughout the year, as judged by the seasonal trends³⁸ of their temperature curves, the Straits of Florida and the region of Cape Hatteras at a comparatively high temperature level, and the Gulf of Maine with relatively low temperatures all year round. We also have two large areas in which a very wide seasonal range in average temperatures is found, namely the Southern and the Middle Atlantic sections of the coastal shallow-water belt with which we are here concerned. The geographical relationships of such neighboring homo-thermal and heterothermal regions to each other have a very important bearing upon many biological problems particularly in connection with the phenomenon of seasonal migrations. In a *heterothermal* region, that is a region in which there is a comparatively great difference between summer and winter temperature, it is clear that the animal communities must either consist of forms which are able and willing to resist these seasonal changes in temperature, or the fauna must suffer a relatively complete change in its composition of species twice a year. In the case of the forms incapable of performing a seasonal migration, the development of a wide toleration for seasonal changes in temperature is, of course, the only possibility offered; but when adequate means of locomotion are provided, such as in fishes and cephalopods, etc., it is simpler and more reasonable to expect a rather

³⁶ On the basis of 5-day periods the seasonal range in the Cape Cod to Nantucket Shoals area may in individual years attain to a magnitude of nearly 30° F., and still higher for single observations due to the great fluctuations occurring in this region during the summer months. (See p. 77.)

³⁷ In Massachusetts Bay temperatures above 60° F. are present more regularly and for a longer period than in the Cape Cod-Nantucket Shoals area, but the maximum limit is approximately the same in both locations.

³⁸ Not by the extreme range of temperatures observed on individual occasions.



complete change in population from summer to winter and vice versa, in accordance with the changes in temperature. As already mentioned such a seasonal alternation in the composition of the shallow-water fish fauna is one of the outstanding characteristics of the Middle Atlantic region, particularly the highly heterothermal southern part thereof. The available information is insufficient to warrant any

Fig. 23.—Average annual surface temperature curves for the five-year period 1881-85, calculated from Rathbun's temperature charts (Rathbun, 1887). First group from the top (*Florida Keys*): Solid line (—): Dry Tortugas. Broken line (---): Carysfort Reef. Dot and dash (- · -): Fowey Rocks. Second group from the top (*Southern Atlantic section*): heavy solid line (—): Marlin Industry. Broken line (---): Rattlesnake Shoal. Dot and dash (- · -): Frying Pan Shoals. Thin solid line (—): Cape Lookout Lighthouse. Third group from the top (*Middle Atlantic section*): heavy solid line (—): Winter quarter. Broken line (---): Five-Fathom Bank. Dot and dash (- · -): Sandy Hook. Two dots and dash (· · -): Block Island. Dot and two dashes (- · ·): Brenton Reef. Thin solid line (—): Vineyard Sound. Fourth group from the top (*Nantucket Shoals, Gulf of Maine*): heavy solid line (—): Nantucket. Broken line (---): Pollock Rip. Dot and dash (- · -): Boon Island. Two dots and dash (· · -): Sequin. Dot and two dashes (- · ·): Matinicus. Three dots and two dashes (· · · -): Mount Desert. Dots (· · · · ·): Petit Manan. The dotted line in the second group from the top represents the average curve for Diamond Shoals Lightship during 1928-30, for comparison with the others.

definite statement as to whether the same is also true of the shallow-water belt south of Cape Hatteras, but a similar course of events should also be expected in that region. Figuratively speaking, one might say that a sufficiently heterothermal region should be expected to be swept entirely clean of its winter population by the northward sweep of the isotherms during the warm season, to be again entirely vacated by its summer population when the isotherms recede again in the fall, the vacating in either direction at alternate seasons having the character of a movement under thermal compulsion.³⁹ If a series of locations with heterothermal conditions at gradually changing temperature levels are arranged in direct continuation of each other, we would obviously simply expect a staggered exchange of populations from north to south during the cold season and in the opposite direction during the summer. If the populations are equivalent to each other, the seasonal change at each location should be qualitative only, but not quantitative. If, on the other hand, conditions in a given area do not at any time of the year become definitely undesirable for the populations present within its boundaries, these populations will not be under any compulsion to move into other regions. When acceptable conditions develop in neighboring areas where they had

³⁹ The compulsion need only be in the sense that thermal conditions within the region being vacated have become definitely undesirable, although they may not involve any immediate physical danger and the act of migration itself may have the aspects of a voluntary reaction. In contradistinction a movement from point to point within an area where conditions are everywhere within the range of the acceptable may be defined as a non-compulsory migration in a population-biological sense, even though the individual movements may well be compulsory reactions to variations within the range of acceptable conditions.

previously been unacceptable the populations might be expected to scatter by random⁴⁰ movements also into these adjacent waters, but this diffusion of populations over a wider range would, of course, be quite different both in its character and in its effects, from the migration of populations as a whole under a thermal compulsion. In sufficiently homothermal regions such compulsion will be reduced or absent and only a seasonal and reversible diffusion of its populations into neighboring regions might be expected to occur. If now a homothermal and a heterothermal region are situated adjacent to each other, it would be likely to occur that the heterothermal region in replacement of the population it compels to vacate its territory in the opposite direction would only receive a seasonal diffusion⁴¹ but not an immigration of complete populations from the homothermal region. If the heterothermal region is situated between homothermal areas on both sides it might thus be expected to remain uniformly poor in migratory forms at all times of the year; and if it should be situated between another heterothermal region in one direction and a homothermal region in the other, it might be expected to show great seasonal variations both in the quality and in the quantity of its migratory populations, being rich during the season in which it is invaded from the heterothermal side, poor when it only receives a diffusion from the neighboring homothermal area. Conversely, a homothermal area situated between or adjacent to heterothermal regions should be expected to be richest when its temperatures show the greatest deviation from those of the surrounding waters.⁴²

In the shallow water belt along the Atlantic coast of the United States, we have several situations to which these considerations might apply. In the Middle Atlantic section we have a heterothermal region with a very rich migratory summer population (fishes). Adjacent to the north is a comparatively homothermal area, the Gulf of Maine. When the summer fishes disappear from the Middle Atlantic coast it is therefore reasonable to expect that the more northern populations would to a considerable extent, at least, replace them by diffusion only,

⁴⁰ Random so far as temperatures are concerned, where no significant temperature differences exist.

⁴¹ The "vacancy" might of course in itself serve to cause an increased diffusion, under favorable conditions perhaps even a total migration.

⁴² If the deviations should be in opposite directions during alternate seasons their effects may, of course, compensate each other so far as a homothermal region between heterothermal areas is concerned.

and not by a total migration. The Middle Atlantic section should, therefore, be expected to be comparatively poor in fish populations during the cold season. This is also found to be the case in an increasing degree the farther one gets away from Cape Cod, with the condition reaching an extreme in Chesapeake Bay, which is reputed to be "largely barren of fish during the winter months" (Hildebrand and Schroeder 1928, p. 13).

The geographical relationships of the homothermal region of Cape Hatteras present a peculiar situation of very particular interest for our biological considerations. Here we have a very small homothermal area interposed between two large heterothermal regions, both deviating from the homothermal conditions during the same season and in the same direction: i. e., by lower winter temperatures. It is thus quite conceivable that the region of Cape Hatteras might receive a winter concentration of "summer" species both from the north and at least from the nearest adjacent waters to the southward. The fact that the autumnal cooling also in the southern region, south of the transition area from homothermal to heterothermal conditions, proceeds from the northward, will of course tend to prevent a northward migration from the more remote parts of the southern region; but within the transition area, at least, such a migration with resultant concentration in the homothermal region seems the most natural thing to expect. There is also the possibility of an indirect northward migration if the midwinter temperature distribution from Cape Hatteras southward is correctly shown in figure 18 on page 53. From this illustration it is evident that if a shallow water fish population for instance in the region between Cape Lookout and Frying Pan Shoals should begin by moving offshore with a certain isotherm between 50° and 60° F., it might continue its migration by moving inshore again in a northerly direction along the same isotherm towards the region of Cape Hatteras. It might, of course, also simply remain in deep water off the region of its summer habitat, or it might even move farther offshore in a southerly direction still along the same isotherm. With these three alternatives in mind the author does not want to express any opinion upon probabilities, but it seems important that the possibility of a northward movement of southern fish populations during the winter towards the region off Cape Hatteras should not be overlooked by the investigators. The mechanism of the winter invasion from the north should not require any further discussion here. It may be seen from

figure 18 that fishes moving with isotherms higher than 65° F. could continue their southward migration through the region of Cape Hatteras and along the Southern Atlantic coast without even being forced to travel offshore. Between 60° and 65° F. they could still pass Cape Hatteras but would be forced to go offshore to the southward, which perhaps in itself might be sufficient cause for them to remain in the region of the Cape. Below 60° F. passage is hardly a significant possibility (see page 56). The ecologically dominant and commercially important summer fish populations of the Middle Atlantic coast arrive in their northern habitat in the spring along with the 45°–55° F. isotherms, thus proving that these temperatures are fully satisfactory for their requirements. This being the case there should be no reason for these species to migrate southward in the winter beyond the region of Cape Hatteras. The forms for which a temperature between 45° and 50° F. is adequate should not even have to travel all the way to the Cape, as their thermal requirements would be fulfilled already in the area immediately north of this point. For the species requiring a minimum sustained temperature above 50° F., but satisfied with 55° to 60° F., the region of Cape Hatteras itself, including particularly the waters immediately to the southwestward of the Cape, would provide perfectly satisfactory winter conditions; apparently in fact more satisfactory thermal conditions than are to be found in any inshore area north of the coast of Georgia or the southern part of South Carolina (Martins Industry Lightship). That a winter invasion of the region of Cape Hatteras and the waters immediately north of this point by the Middle Atlantic summer populations does occur exactly in the manner suggested in the preceding has been clearly established by Pearson's investigation of the winter trawl fishery which has developed in these waters during recent years (Pearson 1932). According to Pearson's findings scup (*Stenotomus chrysops*), sea bass (*Centropristes striatus*), hake (*Urophycis regius*) and other forms satisfied with a temperature of 50° or less, as judged by the temperatures under which they arrive in the north in spring, remain largely north of Cape Hatteras but south of Chesapeake Bay, while the species with a somewhat higher temperature requirement and a slightly later northern arrival such as the croaker (*Micropogon undulatus*), weakfish (*Cynoscion regalis*) and kingfishes (*Menticirrhus* sp.) are mainly found in the region of Cape Hatteras itself, particularly immediately to the southwestward of the point.

Since the Straits of Florida represents another homothermal region it is to be expected that the seasonal invasion of purely tropical forms from this area into the waters of the Southern Atlantic coast must have the character of a diffusion, only, rather than a total immigration. But no actual information of a satisfactory nature is available on this point. In regard to the southward migration of the summer species from the heterothermal waters along the Southern Atlantic coast, it may be pointed out that many of the species such as the weakfish, croaker, etc. have proved their ability to invade the Middle Atlantic region at temperatures ranging as low as 50° F. If the thermal requirements of the southern summer populations of these species are the same, they might consequently be expected to remain all year round south of the Carolinas, where a sustained temperature below 50° F. is not common. Recent investigations have also revealed the presence of the weakfish and others throughout the year along the coast of Georgia.⁴³ The more tropical forms will, on the other hand, undoubtedly be driven farther back towards the Straits of Florida.

STABILITY AND INSTABILITY OF SHALLOW-WATER TEMPERATURES ACCORDING TO TIME AND LOCATION

During the time and in the localities where the isotherms run closely together in groups, as in the temperature barrier in the region of Cape Hatteras during the winter, and the barrier at Cape Cod in the summer,⁴⁴ it is clear that a comparatively slight dislocation of the water masses will cause relatively wide fluctuations in the temperature at any fixed geographical point. We would therefore naturally expect to find highly eurythermal conditions prevailing at such times and in such localities. Where, on the other hand, the isotherms are always fairly well spread out, as in the Southern and Middle Atlantic regions and in the Gulf of Maine, we should conversely expect the seasonal fluctuations to follow an annual curve of fairly smooth contour, with comparatively stenothermal conditions obtaining at any time of the year. These expectations are fully realized in the temperature records now on hand as illustrated by examples in the accompanying

⁴³ The writer is indebted to Mr. W. W. Anderson for winter records from this area.

⁴⁴ If a warm front should develop in the region of Cape Canaveral during the winter (see page 60) it is, of course, also possible that eurythermal conditions might obtain at this point during the cold season. Without actual data available for analysis it is, however, hardly worth while carrying our speculative consideration of this possibility any further in connection with the above discussion.

figure 24. In this illustration we have shown the average annual temperatures for four representative lightships, one for each thermo-

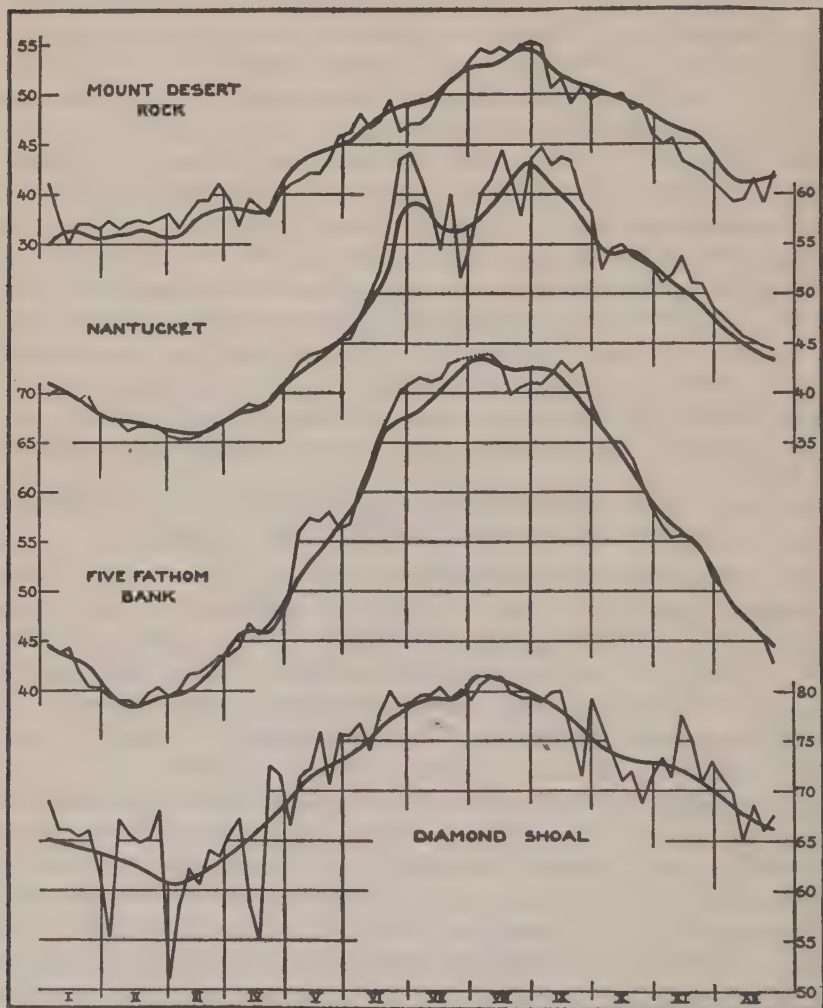


Fig. 24.—Average annual temperature curves for four representative lightships, one for each of the four thermographic regions in the shallow-water zone from Cape Hatteras to the Gulf of Maine (as in Figure 21), with one entirely unsmoothed temperature curve for an individual year in each locality, showing the stability or instability in temperature conditions in the various regions and in the alternating seasons. The curves for individual years are: Diamond Shoals, 1929; Five-Fathom Bank, 1930; Nantucket, 1930; Mt. Desert Rock, 1929. Temperature scales on alternate sides of the diagram.

graphic section of the shallow-water zone from the region of Cape Hatteras to the Gulf of Maine, with an entirely unsmoothed temperature curve for an individual year in each locality drawn around the average curve, to show the amount of deviations from the normal usually encountered in the five-day temperature averages at different times of the year in the different sections of the coastal waters.

From this figure we will see how the individual temperature curves in the shallow-water zone in the region of the Gulf of Maine (Mt. Desert Rock) and of the Middle Atlantic coast (Five-Fathom Bank) run fairly close to the average annual curve at all times of the year, without any significant difference in this respect between summer and winter, quite as we expected.

In the region of Cape Cod (Nantucket), we find the individual annual temperature curve almost entirely joined with the average curve during the winter, spring and late fall, but during the summer, from June to September, that is during the period of the temperature barrier in this region, we find a series of very wide and abrupt deviations from the average, as we were also able to predict from our considerations in the preceding.⁴⁵

In the region of Cape Hatteras (Diamond Shoal) we finally observe the individual temperature averages for five-day periods making by far the widest and most violent fluctuations away from the normal during the winter, early spring and late fall, while the individual curve runs quite close to the average annual curve during the summer period from the end of May to the latter part of September; conditions which are again entirely in accordance with our expectations.

From these considerations we see that whereas the biological processes going on in the shallow-water zone in the Southern and Middle Atlantic regions and in the Gulf of Maine can take place under fairly stenothermal conditions, once the proper average temperature has been reached, the non-migratory organisms living either in the region of Cape Cod⁴⁶ or in the waters around Cape Hatteras will be subjected to very sudden and violent fluctuations in temperature

⁴⁵ It seems probable that observations made near the average centre of the cold area over Nantucket Shoals (see page 31 and figure 5) might show less violent fluctuations in temperature during the summer than do the records from Nantucket and Pollock Rip Lightships, the eurythermal conditions being perhaps a phenomenon of the marginal zones of this cold area, rather than due to fluctuations sweeping the entire region from Nantucket Shoals to Pollock Rip.

⁴⁶ At least around the margins of the cold area over Nantucket Shoals.

during the summer or during the winter, respectively, and they must therefore be able to perform their essential biological functions independent of these changes. The non-migratory fauna must, in other words, be eurythermal in its systematic composition and ecology at least during the summer at Cape Cod and at least during the winter at Cape Hatteras. It would undoubtedly be very interesting to have the invertebrate bottom faunas of these two widely separated regions of the shallow-water zone worked out and compared with each other, and with the faunas of the intervening area, with due consideration of the zoogeographical and ecological significance of this state of eurythermal and stenothermal conditions in opposite seasons and in opposite alternation with each other in the different regions. It may, in this connection, also be of interest to point out that the eurythermal conditions in the Cape Cod and in the Cape Hatteras regions, although at entirely opposite seasons of the year, nevertheless occur around almost exactly the same average temperature, namely, about 60 degrees F.

That the fluctuations occurring during the eurythermal periods at Cape Hatteras and at Cape Cod are large enough to call for further investigation of their biological effects should be adequately shown in our figure 24, from which it may be seen that successive five-day averages in the former region during the winter period may differ from each other by as much as 17-18 degrees F., and in the Cape Cod region fluctuations of about the same magnitude may occur within the period of about three weeks during the height of the summer. If individual daily or semi-daily records are considered, differences of as much as 11 degrees F. within ten hours or 20 degrees F. within two days may be registered at Cape Hatteras, and at Nantucket Lightship differences of as much as 13 degrees F. may develop overnight.

That the recorded observations are not simply accidental and due to errors of observation can be taken to be proved beyond any reasonable doubt by the fact that the data furnished by the officers of two separate lightships in each barrier region (Pollock Rip and Nantucket Lightships for the Cape Cod region; Diamond Shoal and Cape Lookout⁴⁷ Lightships for the region of Cape Hatteras) in three separate

⁴⁷ As one may see from figure 21 the temperatures at Cape Lookout Lightship will register the approach or withdrawal of the Gulf stream towards or away from the coast in a similar manner as does the temperatures at Diamond Shoals. Similar effects are also to be observed at Frying Pan Lightship (example in figure 25, on next page), although somewhat less frequently and less violently.

years (1928–1930) give essentially the same picture of the annual temperature cycles in these waters, while the temperature data obtained from the lightships and lighthouses along the Middle Atlantic coast (Cape Charles, Winter Quarter, Five-Fathom Bank, Fire Island, and Brenton Reef) and in the Gulf of Maine (Portland and Mt. Desert Rock) are in equally good agreement with each other in showing a comparatively smooth and uniform development of the annual temperature curves in the respective regions to which they belong. The writer has considered it unnecessary to render in print each of the

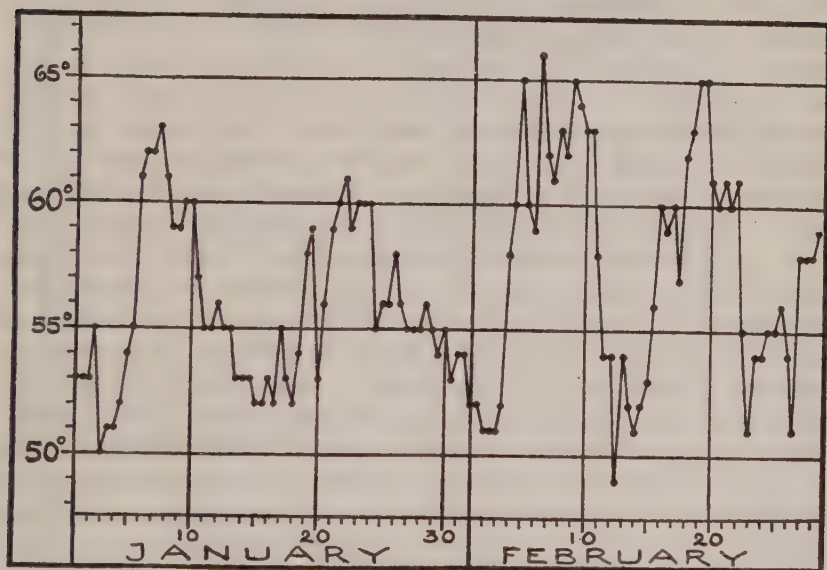


Fig. 25.—Unsmoothed temperature curve for Frying Pan Shoal Lightship during the months of January and February 1929. Observations twice daily.

twenty-seven annual temperature curves for these nine lighthouses and lightships in substantiation of these assertions, but has intentionally chosen for illustration in figure 4 (page 22) the one individual annual temperature curve which apparently differs most from what has in the preceding been claimed to be the normal conditions of the region to which it pertains, namely, the 1930 curve for Diamond Shoal. In this year there appears to have been a period of comparatively stenothermal conditions during the coldest part of the year, but the abrupt fluctuations in the beginning of February, the end of May and first days of

June, and the late fall (the December records are, unfortunately, still missing for this year) otherwise confirm our general description of temperature conditions in the region of Cape Hatteras, as do also the 1930 records from Cape Lookout.

From the foregoing use of the terms stenothermal to describe conditions in regions where the annual temperature curve has a very wide seasonal range, and eurythermal for conditions where the seasonal difference is comparatively slight, it may already have occurred to the reader that the conventional terminology differentiating only two categories of temperature conditions is really quite inadequate to describe the situations actually found in nature. Among the chief features to consider in a classification of thermal conditions for biological purposes are: 1) the irregular fluctuations of short duration around the average trend of the season; and 2) the regular, periodic changes in average temperature levels from season to season. It is clear that the ability of an organism to withstand great, but slow and gradual changes in temperature from season to season does not necessarily imply that it is also able to resist a series of violent fluctuations within a short period. Nor can it *a priori* be taken for granted that a species with great resistance to sudden changes in temperature of short duration must be equally well able to survive a similar change sustained throughout a whole season. Short-period and seasonal fluctuations must, therefore, be considered separately as two entirely different and independent biological factors in our definition of an ecological environment and in this manner we arrive at a quadruple instead of simply a double classification of temperature conditions, for which the author will propose that the following terms be used: *Homostenothermal* for the regions of greatest stability in every respect; that is, where the regular difference between the seasonal temperature-levels as well as the irregular fluctuations around the seasonal trends of the temperature curve are slight; or for organisms requiring such conditions for their existence. *Heterostenothermal* for regions in which the irregular fluctuations are slight, but the seasonal differences great; or for organisms able to exist under such conditions. *Homoeurythermal* for regions in which the seasonal differences in average temperature level are slight, but the irregular fluctuations around the seasonal averages, or trends, are great; or for organisms able to exist under such conditions. *Heteroeurythermal* for the regions of least stability; that is where both the regular seasonal differences and the

irregular fluctuations are great; or for organisms able to exist under such conditions. The accompanying figure 26 gives a diagrammatical

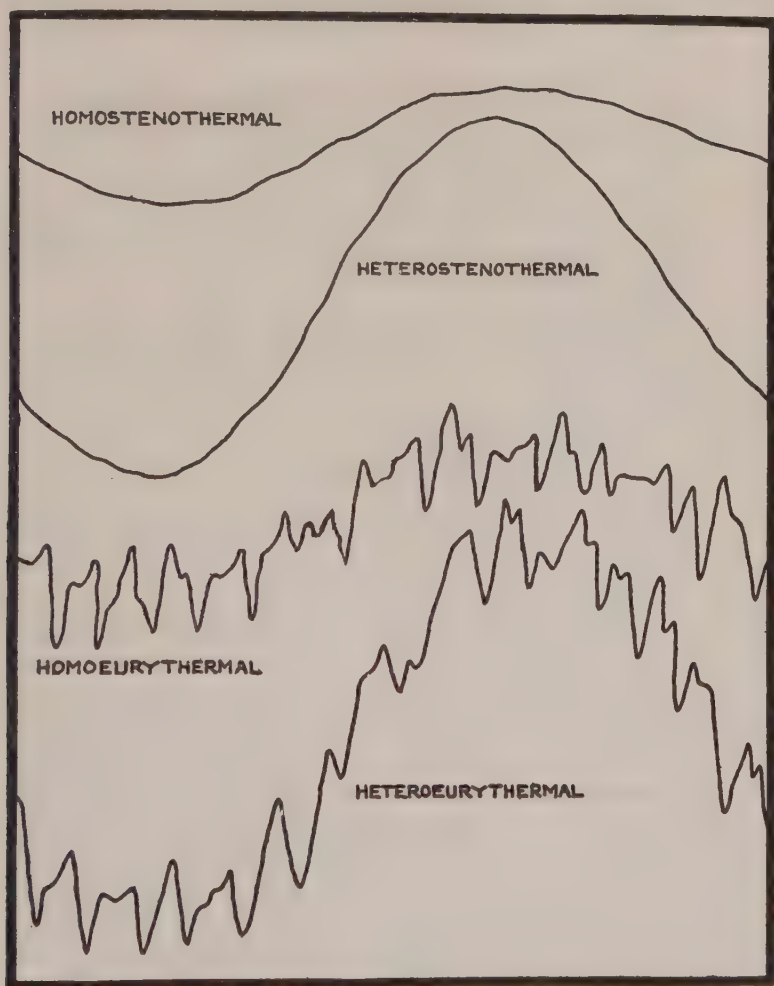


Fig. 26.—Diagrammatic illustration of the four main cathegeries of temperature conditions.

illustration of the four types of temperature conditions. In the case of the two eurythermal types, the irregular fluctuations may, of course, be seasonal in their occurrence and need not take place during the

whole year. This will, therefore, require special mention in the definition of any eurythermal region and it may correspondingly be worth while investigating whether eurythermal organisms may not show a wider toleration of irregular fluctuations at certain temperature levels than at others.⁴⁸

In the shallow-water belt along the Eastern coast of the United States we have comparatively homoeurythermal conditions in the region of Cape Hatteras; more heteroeurythermal conditions in the region of Nantucket Shoals; heterostenothermal conditions in the Southern and Middle Atlantic bights; homostenothermal conditions in the Straits of Florida and to a lesser degree towards the northern part of the Gulf of Maine.

Even the quadruple classification of temperature conditions is, of course, only adequate so long as we deal with organisms and processes completing their cycle within a year. But in the study of geographical distribution, the evolution of species, and the history of populations we also have to consider the variations in temperature conditions from year to year, and the ability of species and populations to adapt themselves, reversibly or irreversibly, to these variations. Through the great attention lately directed towards the long-term periodic fluctuations in the abundance or in the distribution of a multitude of organisms, the question of periodic or non-periodic annual variations in temperature has gained a particular interest in modern ecology, and in the problems of palaeogeography and the evolutionary history of the species it has always been an outstanding feature for consideration. For this reason it is also desirable to have well-defined terms for the designation of secular stability or instability of temperatures and for the ability or inability of populations and species to withstand or adapt themselves to changes in temperature conditions involving periods longer than a year. To that end the author will propose the use of the term *monimothermal*⁴⁹ for temperature conditions remaining relatively constant from year to year; or for species and populations requiring such stability for their continued existence in a certain

⁴⁸ It is not at all to be taken for granted that the widest toleration for eurythermal conditions should be found in the middle of the temperature range of a species, as physiological changes determined by the general temperature level may quite conceivably have a profound effect upon the ability of the organism to withstand the adversity of sudden fluctuations.

⁴⁹ Monimos = constant.

region; and *reothermal*⁵⁰ for temperature conditions showing great variations from year to year, whether of a periodic or nonperiodic character; and for species and populations able to resist or adapt themselves to such variations.

TEMPERATURE CONDITIONS IN SEMI-ENCLOSED AREAS IN RELATION TO SHALLOW-WATER TEMPERATURES OFF THE OPEN COAST

As already well known, and mentioned on several occasions in the preceding, the laws governing the temperature cycle in the sea off the open coast do not generally apply equally well to temperature conditions in the semi-enclosed areas of marine water extending inwards from the outer shoreline in such regions as, for instance, Chesapeake and Delaware Bays, and in the inland water-ways of the New Jersey marshes, et cetera. In such localities, one will, of course, almost invariably find that the annual temperature curve has a considerably greater range than in the waters immediately outside, with lower temperatures in the winter and higher during the summer. In the accompanying figure 27 a comparison is made between the surface temperatures recorded at Five-Fathom Lightship and the temperatures observed by the writer and his collaborators inside of the Delaware Bay. While this picture in itself only represents a situation with which every marine biologist has already long been familiar, it nevertheless implies the possibility of certain ecological dangers, which, so far as the author knows, have not heretofore received the attention they might merit in special cases. When the bay water temperatures follow a different curve from that taken by the temperatures on the outside, the situation might, so far as we know, quite possibly arise that the two temperature curves would not intersect during the autumnal cooling until they had both sunk considerably below their modal values during the summer. Whenever this should happen to be the case, summer populations established in inside waters by a warm-water species, for which it should be imperative to avoid temperatures as low as that of the intersection point between the inside and outside temperature curves, might quite easily get trapped and destroyed by the fact that they would not take alarm and leave until the temperatures of the outside waters through which they would

⁵⁰ Reo = to be in constant state of change.

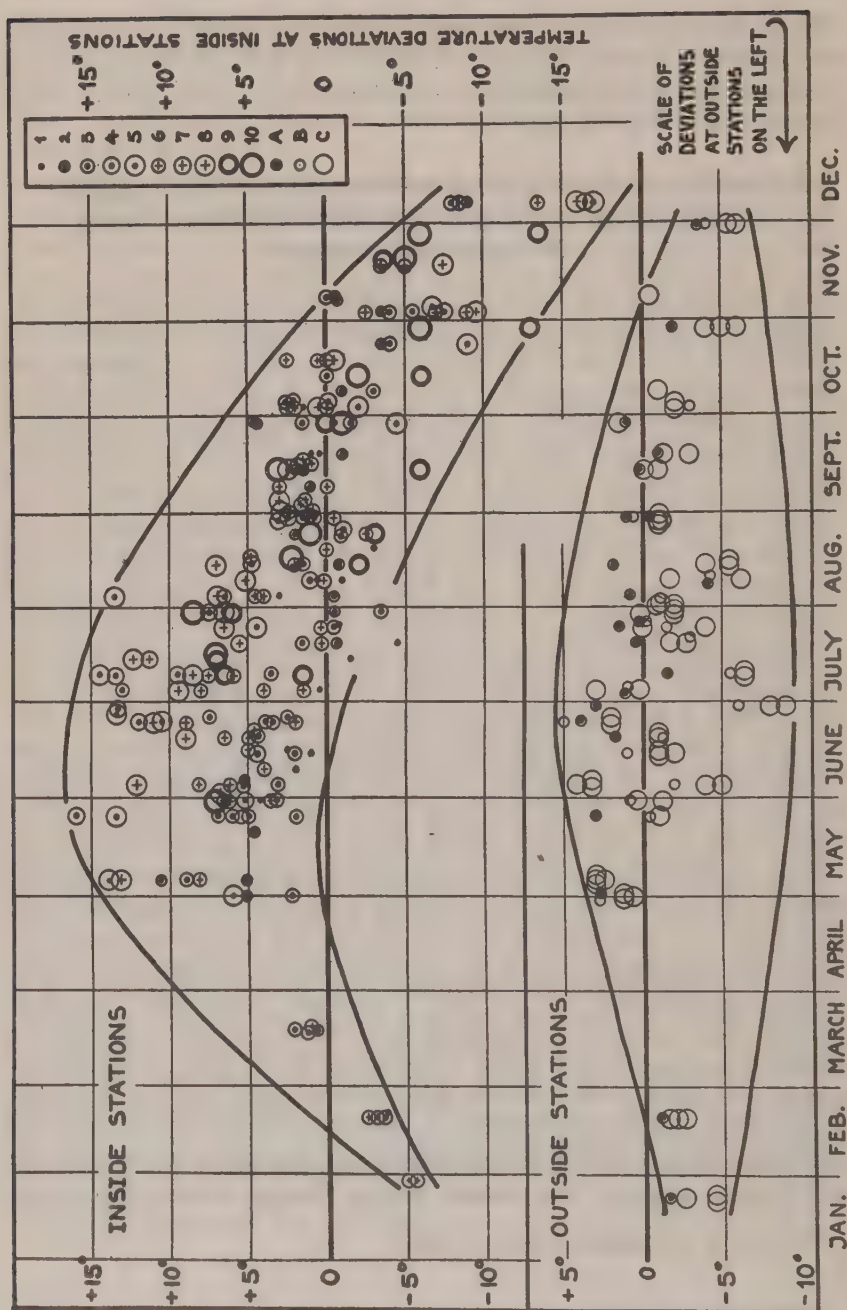


Fig. 27.—Deviations from the Five-Fathom Lightship records shown by the temperature data, collected by the writer and his collaborators at inside and outside stations in the Delaware Bay region during the years 1929–1930. The station symbols for the inside locations have been so drawn that an increasing total diameter will indicate increasing distance from the mouth of the bay. Scale of deviations in degrees Fahrenheit on the left.

Symbols: 1, Overfalls Shoal. 2, Ricord Channel and gully east of Brandywine. 3, region off New England Creek. 4, Dennis Cove. 5, Dennis Creek (salt to brackish). 6, outer stations on the Delaware side of Delaware Bay. 7, Mispillion Cove. 8, Mispillion Creek (salt section near mouth). 9, Dennis Creek (brackish to fresh section). 10, Maurice River (brackish to fresh). A, Inner edge of Five-Fathom Bank. B, West of Five-Fathom Lightship. C, Other outside stations in the Delaware Bay region.

have to pass had already sunk below the minimum temperature required for their well-being, while they were still dwelling in warmer waters inside. Even when the temperature on the inside should finally begin to approach the minimum value for our species, the temperature gradient might still be pointing in the wrong direction, inwards instead of outwards, and might thus continue to keep the population captive until disaster set in, before the gradient would finally turn to point in the proper direction after the intersection point between the inside and outside temperature curves had been passed. For this reason it seems desirable always to try to establish the nature of the seasonal relations between the inside and outside temperature cycles wherever there are bays or other more or less enclosed shallow-water areas of sufficient magnitude to constitute real zoogeographical dangers in case conditions such as those described in the preceding should develop.

To see if any such dangers might be found within the area with which we are here concerned, the average relationship between the Delaware Bay temperatures and the temperatures of the immediately adjacent waters on the outside has been indicated in figure 28 by drawing the three-year average temperature curve for Five-Fathom Bank Lightship, based upon twenty-five-day periods, and by constructing an inside temperature curve from this on the basis of mid-point values⁵¹ in the deviation band for the Delaware Bay temperature observations given in the upper part of figure 27.

From figure 28 it would seem that apparently no danger is involved in so far as Delaware Bay is concerned, inasmuch as the autumnal intersection point is very close to the modal point of both curves,

⁵¹ Averages would not give a just illustration since the number of inside observations in various localities cannot be evaluated according to the length of time and the extent of the area they represent.

so that the temperature gradient is henceforth pointing in the right direction as far as the emigration of all southern forms at the approach of winter is concerned. Similarly, the vernal intersection point is very close to the minimum values reached by both curves during the cold season, so that it is also a perfectly safe area for the escape of the winter fish to the northward with the advance of temperatures during the spring. It is quite possible that this picture represents the normal state of affairs under topographical conditions such as those of the Delaware Bay region and of the Middle Atlantic

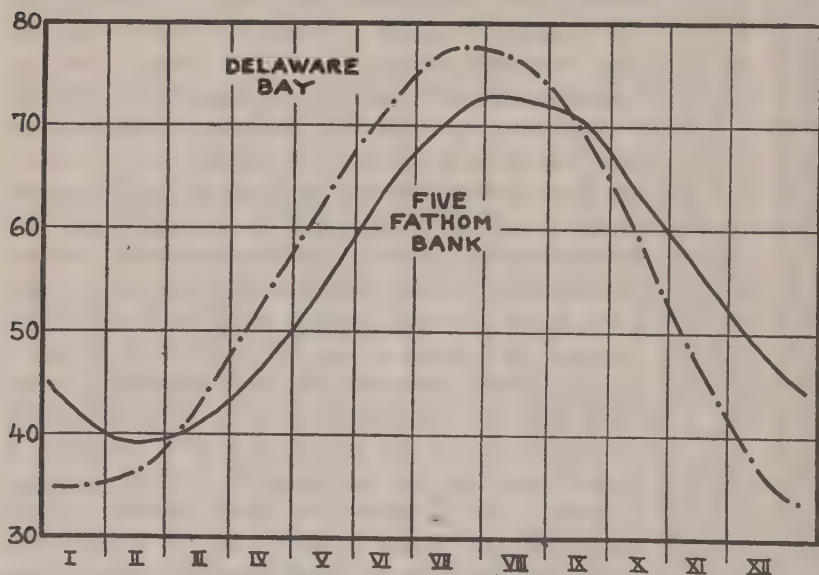


Fig. 28.—Average annual temperature curves inside and outside of the Delaware Bay. Explanations in the text.

coast in general⁵² and that one will not often meet with any actually important zoogeographical traps of the nature described in the preceding. Nevertheless, it will always remain a possibility to be looked out for in marine ecological investigations.

The relationship of the temperatures observed at Boston Bay Lightship and at Gloucester to the temperatures recorded from the

⁵² If both temperature cycles are solely determined by vernal heating and autumnal cooling, without hydrodynamic complications, this would perhaps even seem to be the generally most probable state of affairs to be expected under such circumstances.

nearest stations on both sides (Pollock Rip and Portland, Maine) rather indicates that conditions in the former two localities must be regarded as similar to those of semi-enclosed areas such as Delaware Bay. Allowance for this fact has therefore been made by the preparation of figures 8-11 on various occasions when the full consideration particularly of the Gloucester records would tend to distort the pictures too much.

SUMMARY AND CONCLUSIONS

Daily temperature records kept by 19 lightships and lighthouses along the eastern coast of the United States from Tortugas to Maine, over a period of three years (1928-30), together with the temperature curves rendered by Rathbun (1887) for the period 1881-85, are analyzed and presented for biological consideration without any attempt to interpret them hydrographically.

The recorded surface temperatures are considered to be in a general way representative of temperature conditions in the entire shallow water zone (off the open coastline) down to an average depth varying from 5 fathoms during the summer to probably more than 20 fathoms during the winter.

The special geographical significance of the shallow water zone along the Atlantic coast of the United States is pointed out and it is shown that the area within the 10-fathom contour covers over 10,000 square miles between Cape Cod, Mass. and Cape Canaveral, Florida, with an average width over this distance of more than 10 miles.

A method of presentation is selected which gives a clear picture of the annual temperature cycle of the entire shallow-water zone at once, both in relation to time and to geographic location, thereby also bringing out the seasonal changes in the interrelationships between the various coastal regions with respect to temperature.

It is found that the periods and regions of change in regard to temperature also define the time and location of the major migratory activities of the shallow-water fish populations.

A warm-water temperature barrier is established in the region of Cape Hatteras during the winter, separating the colder coastal waters to the southwestward from the cold waters to the north; while a cold-water barrier develops in the region of Cape Cod-Nantucket Shoals during the summer months; but in neither locality are such barriers found to be a permanent feature during all seasons. The possibility

of a warm wall, or warm front, being formed somewhere in the region around Cape Canaveral during the cold season is also discussed, but the available data are inadequate to show whether such a development actually takes place or not.

Through the alternate development and breakdown of the temperature barriers at Cape Hatteras and at Cape Cod, the shallow-water belt along the Middle Atlantic coast between these two points is in open temperature-continuity with the waters north of Cape Cod during the winter and with the waters south of Cape Hatteras during the summer, being barred in the opposite directions during these respective seasons. These observations are found to explain both the period, extent and character of the seasonal invasions of the Middle Atlantic coastal waters by populations of northern or of southern origin.

The shallow-water belt along the eastern coast of the United States is shown to contain three relatively homothermal areas, that is, areas in which the seasonal variations in temperature are comparatively slight, namely the Straits of Florida at a high temperature-level, the region of Cape Hatteras at an intermediate level, and the Gulf of Maine at low temperatures. The seasonal range in these areas is least in the Straits of Florida and greatest in the Gulf of Maine, which is designated as homothermal only in comparison with the other two major regions of the shallow-water zone: the Southern and Middle Atlantic Bights, in which highly heterothermal conditions are found to prevail, that is, where the seasonal variations in temperature are very great.

The ecological relationships between homothermal and heterothermal regions adjacent to each other in various arrangements are discussed and reasons are found why the winter invasion of the Middle Atlantic region from the north should be quantitatively poor and not very penetrating, why the seasonal change in the composition of the fish fauna of the Middle Atlantic Coast should be as complete as it is, and why the winter concentration of summer fish recently discovered in the region of Cape Hatteras should be expected to occur exactly at that point.

While the temperatures in the Straits of Florida, in the Southern and Middle Atlantic regions and in the shallow-water zone in the Gulf of Maine follow a fairly smooth annual curve through all seasons, providing fairly stable conditions for stenothermal species and bio-

logical processes at any time of the year, the temperatures in the Cape Cod region develop smoothly only during the winter, early spring and late fall, but show violent fluctuations during the summer months. In the neighborhood of Cape Hatteras, the opposite succession of conditions prevail, with a relatively smooth temperature curve during the summer, but with violent fluctuations during the winter, early spring and late fall.

At Cape Cod and Cape Hatteras one thus finds strongly eurythermal conditions of life prevailing during opposite seasons, in alternation with stenothermal conditions around an only gradually changing temperature trend during the rest of the year. The desirability of an ecological investigation of the shallow-water bottom faunas with a view to ascertaining the possible effect of these conditions is pointed out.

Attention is called to the fact that the eurythermal conditions develop around approximately the same average temperature of about 60 degrees F. at Cape Cod in the summer and at Cape Hatteras during the winter. The fluctuations during the eurythermal periods in these regions may cover a range of as much as 20 degrees F. within two days.

It is pointed out that the classification of thermal conditions, in regard to stability or instability, or of the thermal requirements of the organisms in this respect, in two categories only, eurythermal and stenothermal, is quite inadequate for the description and definition of the conditions and requirements actually found in nature. At least four categories are shown to be needed for an elementary classification of the main types of thermal fluctuations within the annual cycle, and at least six categories when variations over longer periods than one year are also being considered. Suitable terms for the designation of the six main types of temperature conditions, and of biological requirements in regard to stability or instability of temperatures, are suggested (p. 80).

The relationship between the water temperatures in semi-enclosed areas and in the shallow-water zone along the open coast line is discussed, and the possibility of such semi-enclosed areas acting as temperature death traps for the migratory forms, depending upon the direction in which the temperature gradient may point at the time when the outside temperature reaches the danger point for any particular species, is pointed out, but it is found that such temperature traps probably do not normally develop in the bays and inland salt waters of the coastal area here considered.

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TABLE FOR CONVERSION OF TEMPERATURES FROM DEGREES
FAHRENHEIT TO DEGREES CENTIGRADE

<i>Fahrenheit</i>	<i>Centigrade</i>	<i>Fahrenheit</i>	<i>Centigrade</i>	<i>Fahrenheit</i>	<i>Centigrade</i>
30	-1.11	50	10.00	70	21.11
31	-0.56	51	10.56	71	21.67
32	0.00	52	11.11	72	22.22
33	0.56	53	11.67	73	22.78
34	1.11	54	12.22	74	23.33
35	1.67	55	12.78	75	23.89
36	2.22	56	13.33	76	24.44
37	2.78	57	13.89	77	25.00
38	3.33	58	14.44	78	25.56
39	3.89	59	15.00	79	26.11
40	4.44	60	15.56	80	26.67
41	5.00	61	16.11	81	27.22
42	5.56	62	16.67	82	27.78
43	6.11	63	17.22	83	28.33
44	6.67	64	17.78	84	28.89
45	7.22	65	18.33	85	29.44
46	7.78	66	18.89	86	30.00
47	8.33	67	19.44	87	30.56
48	8.89	68	20.00	88	31.11
49	9.44	69	20.56	89	31.67

A CONTRIBUTION TO THE STUDY OF THE NATURAL FOOD-CYCLE IN AQUATIC ENVIRONMENTS

WITH PARTICULAR CONSIDERATION OF MICRO-ORGANISMS AND
DISSOLVED ORGANIC MATTER.¹

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INTRODUCTION.

August Pütter¹ contended that most aquatic animals must of necessity derive the major part of their nutriment from *dissolved* organic matter in the waters, and that these dissolved substances must be taken up through the integument and gills, rather than through the gut.

This theory has been the subject of several discussions,² the most extensive of which is that of Krogh (1931).

Pütter's theory, even in its strictest sense, embraces a large field, but in the development of the literature of the subject, the whole of aquatic ecology, plant and animal, marine and fresh water, has been taken into consideration. The number of investigators has been very large, but their particular scope of interest has often been limited, so that some of the relevant fields have been very fully explored, while others, equally important in a consideration of the theory as a whole, have been insufficiently studied, and in some cases, almost totally neglected.

In fact it has certainly been shown that Pütter's original reasoning

¹ 1907a, 1907b, 1909a, 1909b, 1911, 1912, 1914, 1922, 1923, 1924a, 1924b, 1925. Of these 1909b is the most complete.

² Other careful treatments are those by Lipschütz (1913), Krízenecký (1925a, 1925b), Ranson (1927), and Gran (1927).

does not hold. There is even good reason to doubt the probability that parenteral feeding plays any important role in marine economy, entirely aside from the shortcomings of the statistical and experimental methods of Pütter.

However, much of the literature of the subject is concerned with proving Pütter's arguments invalid, rather than in an attempt to discover the actual source of the food of the zooplankton. Consequently much of the evidence on the problem as a whole is a result of analogy and is circumstantial instead of being derived from observation and experiment. Entirely aside from Pütter's reasoning, the possibility that the zooplankton may obtain an important part of their food from solution has not been eliminated by experiment.

For example, there is very little accurate knowledge of the quantities and ratios of dissolved organic matter, organic matter in the nanoplankton, and organic matter in the net-phytoplankton. And while it was pointed out by Lohmann (1908 etc.) that the nanoplankton probably divides rapidly and is thus more important as a possible source of food than had been believed, he arrived at no quantitative results other than by very rough estimate. And finally, all of the experiments which have been carried out on the actual parenteral feeding of aquatic forms have been done: (a) with inadequate control of the particulate food available, or (b) under such unnatural conditions that their results are more or less irrelevant to a consideration of life in the sea, or (c) on animals which, for one reason or another, are entirely unsuitable for such experimentation.

It therefore seemed proper to try to discover more about the absolute and relative quantities of possible foods in the sea—especially concentrating upon the nanoplankton; and also to experiment on parenteral feeding, with a suitable animal, under most carefully controlled conditions.

Accordingly such a program was undertaken, and experiments and observations were made whenever they seemed necessary to expand or substantiate the facts contained in the literature, or to fill in gaps in the knowledge.

It might be mentioned that this undertaking was begun about a year before the appearance of Krogh's paper, and a complete review of the literature was originally planned to accompany the account of the experimental work, but Krogh's publication has obviated the need for such a general treatment. Therefore, there will be discussed

in detail only certain relevant papers not considered by Krogh; a few papers in the interpretation of which I disagree with this author; and certain aspects of his own review.

THE DISSOLVED ORGANIC MATTER IN NATURAL WATERS.

a. QUANTITATIVE CONSIDERATIONS.

It is an absolute necessity, of course, that there should be dissolved organic matter in sea water if the zooplankton is to feed in any degree parenterally. Likewise, such dissolved organic substances as may be present must be suitable as food. Or, to reverse the view-point: *animals which are to depend on absorbing solutions must be able to use whatever substances may be dissolved in the sea, and in such quantities as may exist.* Thus it is of fundamental importance to consider what is known of the dissolved organic matter in sea water.

The question of the sources of dissolved organic matter in sea water has been well treated by Krogh except for one point which may be elaborated as follows: Pütter (1924a), working with cultures of algal plankton, came to the conclusion that a large part of the material synthesized by the diatoms passes into solution in the sea water. His explanation is that the surface area of the phytoplankts is relatively so enormous that they are unable to retain their food as they synthesize it, and a large part of it diffuses out into the medium.

Gran and Ruud (1926) kept flask cultures of Phytoplankton, and compared the O_2 given off with the mass of diatoms produced, and on their evidence Gran (1927) definitely concludes that 80–90% of the matter synthesized by the diatoms is given off into solution. But Marshall and Orr (1930), working with single species of diatom, obtained entirely negative results, though it must be admitted that their work was much less careful than that of Gran and Ruud. And Krogh, Lange and Smith (1930) working with a pure culture of *Scenedesmus* found, over a considerable period, that less than 5% of the total organic matter produced escaped into the medium. With plankton from natural waters, they found a maximum of 10% given off. With considerable reason, they assign much the greater part of this to dead and disintegrating cells. These experiments were made in fresh water, the bacteria were accounted for, and the analyses were extremely careful, so that the results are extraordinarily reliable.

Krogh appears to doubt the validity of the work of Gran and his

associates, suggesting that dying cells in the cultures may account for their results. Another probable source of error in their work seems to escape him. These authors, from the oxygen given off, determine the weight of synthesized matter theoretically produced as carbohydrate, using a formula of the type:



But it is well known that in fact diatoms produce and store fats rather than carbohydrates, as was shown by Beijerinck (1904a). The nature of such fats is not very well known,³ but as the fats have relatively similar proportions of carbon, hydrogen and oxygen in their makeup, we can assume a neutral fat containing one molecule each of oleic, palmitic and stearic acids, with a formula $\text{C}_{55}\text{H}_{104}\text{O}_6$. Now if we construct an equation for its formation from carbon dioxide and water we get:



In the case of carbohydrate, 1 gram of oxygen means the formation of .94 grams of glucose; whereas the same amount of oxygen represents the formation of only .34 grams of fat. Gran and Ruud found an increase in weight of the diatoms of only about .14 grams per gram oxygen produced, and hence concluded that .80 grams carbohydrate had been formed but lost into the water. On the basis of fat synthesis 1 gram O_2 with a gain in diatom weight of .14 grams would leave only .20 grams formed material to account for as compared with their .80 grams.

It makes little difference in the end result whether the synthesis of the fats takes place with the photosynthesis of carbohydrate as the initial step, or whether the photosynthesis of fat takes place directly. In either case there will be a by-product of far more O_2 than from the formation of carbohydrate alone, and the higher the fatty acid synthesized, the greater will be the weight of O_2 produced per gram of organic matter.

b. QUALITATIVE CONSIDERATIONS.

This is well covered by Krogh both as to the little known about sea water and the inferences to be drawn from observations on the

³ The partial analysis made by Hashimoto (1927) of oil from *Aulacodiscus kittoni* is not very enlightening.

water of lakes and ponds. The residual, soluble products of organic disintegration in natural waters are very resistant to the action of bacteria and other forms of life. But it is necessary to emphasize that though these residual products, which constitute much the greater part of the total dissolved organic matter in the sea, are relatively very resistant to bacterial action, none the less, the first substances of organic disintegration may probably be very suitable as nourishment for those forms that are present along with them, and that have a life cycle sufficiently short. This argument will be elaborated subsequently.

C. ANALYTICAL METHODS FOR QUANTITATIVE DETERMINATIONS
OF THE DISSOLVED ORGANIC CONTENT OF NATURAL WATERS.

Methods of estimating the organic matter that have been used for sea water are: (a) carbon dioxide obtained by wet combustion with chromic acid, (b) nitrate nitrogen + nitrite nitrogen + nitrogen in free ammonia; subtracted from total nitrogen, (c) oxygen taken from potassium permanganate to oxidize the organic matter in sea water, and (d) oxygen consumption by bacteria in using up the organic matter.

The advantages and faults of these methods and the figures obtained from them are discussed by Krogh. They are all more or less tedious and inaccurate, and the figures are consequently unreliable. The permanganate method which is the most rapid and simple gives minimum values, as all the organic matter is not oxidized. By this method Moore, Edie, Whitley, and Dakin (1912a) found about one mg. of organic matter per liter in the Irish Sea; and Föyn and Gran (1928) by this and the bacterial method found an oxygen capacity between .39 and 2.53 mg. per liter in Norwegian waters. The figures for off-shore waters seem generally to lie between .05 and 10 mg. O_2 as furnished by $KMnO_4$ to oxidize the dissolved organic matter in 1 liter.

Krogh notes that Pütter fails to tell how, or if, he filtered his water samples before making his determinations, but even in the work of Gran and others, the bacteria, other microneoplankts, and probably very fine detritus was not adequately removed. Gran used hardened filter paper, but this allows most bacteria to pass, so that all such figures will have to be reduced by an amount representing the bacteria etc. in the filtrate.

Investigation of the permanganate method.—Because of its simplicity, and the number of samples to be analyzed, the permanganate method was decided upon for the present investigation.

It is known that many organic substances are only partly oxidized by permanganate, but as the main purpose of the work was to determine relative quantities, it was thought that the method would be sufficiently exact. The enormous inaccuracy introduced by the liberation and oxidizing action of the chlorine on the addition of acid was not appreciated at the time.

However, a series of 30 test determinations was made on a large sample of Friday Harbor water, using the method given in *Standard Methods of Water Analysis*⁴—Digestion of the sample with alkaline permanganate, acidulation, addition of excess ammonium oxalate, and black-titration with permanganate. It was found that not only was the end-point very uncertain under these circumstances, but even with the most carefully controlled conditions there was a difference amounting in extreme cases to more than 50% of the maximum obtained, and the probable error was very large. The method was varied considerably, being tried in the cold as by Moore and collaborators (1912a) and in acid medium, and with varying periods of digestion. In no case were the results satisfactory.

The same unreliability was found when the water treated was a practically organic-free synthetic sea water to which a known quantity of dextrose had been added.

The greater part of the summer was spent in trying various modifications of the permanganate method, and one was finally arrived at which gave results very close to the expected in the case of dextrose in synthetic sea water and a maximum difference of about 15% of the largest figure obtained, and a probable error of about 2.5% in a large series of natural sea water. This seemed sufficiently accurate, and the samples were analyzed by this method.

The analytical procedure.—To 20 cc. of the water to be analyzed was added 5 cc. of a 50% solution of AgNO_3 . This is greatly in excess of the quantity needed to precipitate all the chlorides, but it was found that this excess was necessary to prevent liberation of free chlorine during the subsequent treatment.

To the flask containing the sample was added 10 cc. of a solution of KMnO_4 of such strength that 1 cc. represented 1 mg. available

⁴Third ed. 1927. American Public Health Association, N. Y.

oxygen, and 10 cc. of 9N.H₂SO₄ was then added, and the flask kept for 10 minutes in boiling water.

10 cc. of ammonium oxalate solution was then added, and the liquid titrated back to a faint color with the permanganate. The oxalate solution was made up so that 1 cc. of the solution exactly decolorized 1 cc. of the permanganate. The number of milligrams of oxygen needed for oxidation of the organic matter in the sample could thus be read directly from the burette containing the permanganate solution.

d. INVESTIGATIONS IN EAST SOUND.

Relation of the nannoplankton to dissolved material.—The findings of Fish (1926) (Cf. Fig. 1) show that the zooplankton and phytoplankton maxima often follow each other by a considerable interval. This could hardly be explained by Pütter's theory, for, as Gran and

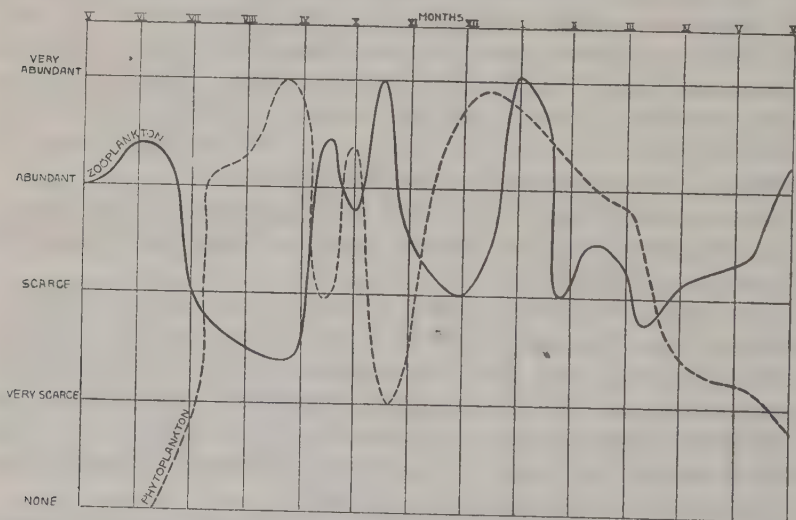


Fig. 1. Abundance of phytoplankton and zooplankton in the Woods Hole region, through parts of two years. (After Fish (1926).)

Ruud (1926) remark, it must be suspected that a great part of the organic material produced in dissolved form by the algae will immediately be oxidized by the bacteria, and only little will be left for the animals to use. And the same action may well be performed by other nannoplankts which have a short enough life cycle to take

immediate advantage of such a food supply by rapidly increasing to enormous numbers. In fact, Fish himself notes: "Within three days after the bulk of the diatoms disappeared, two species of protozoa fairly swarmed in the plankton," and Gran and Ruud (1926) observe that after the great maxima of the pelagic diatoms there follows a swarming of colorless gymnodinia such as *Gymnodinium lohmanni* and of ciliates such as *Lohmanniella oviformis*, which, they suggest, probably feed in part on dissolved matter and in part on bacteria.

It therefore seemed extremely probable that careful determinations would show a considerable growth of nannoplankton *after* the diatom maxima, which would, so to speak, fill in the food-gap between the maxima of the diatoms and those of the zooplankton. At the same time the successive quantities of dissolved organic matter during the same period could be determined.

It was thought most desirable to begin the determinations at a diatom maximum and continue them through a succeeding zooplankton maximum. Accordingly the waters chosen for the work were those of East Sound, Orcas Island, State of Washington, as it was known that diatoms were present there in very large numbers about the 1st of July, when it was convenient to undertake the work, and as the Friday Harbor Oceanographical Laboratories, where the determinations could be made, were situated at a convenient distance.

Description of East Sound.—East Sound is a body of slightly dilute sea water (salinity about 29–30 parts per thousand), connected by deep passages with Rosario Strait and with San Juan Passage, and by them to the Strait of Georgia and the Strait of Juan de Fuca, and through the latter with the Pacific Ocean which lies approximately 100 miles away.

East Sound is about 7.5 miles long by .65 to 1.5 miles wide. It has a maximum depth of about 20 fathoms, and a raised sill, with a maximum depth of about 10 fathoms, runs across its mouth. The maximum tide range is roughly 9 feet from minimum low to maximum high or about 7 feet from a low to the subsequent high (see Fig. 2).

The station chosen for sampling was about .25 mile in past the sill and equidistant from the shores, with 16 fm. at mean lower low water. The position may accurately be determined by the alignment of conspicuous landmarks. Accurate records of the temperatures were not kept. The surface temperature on the date of first sampling was about 11° C. with 9.5° C. at 10 meters. Temperatures of about

16° C. at the surface and 11° C. at 10 meters were reached toward the end of the season.

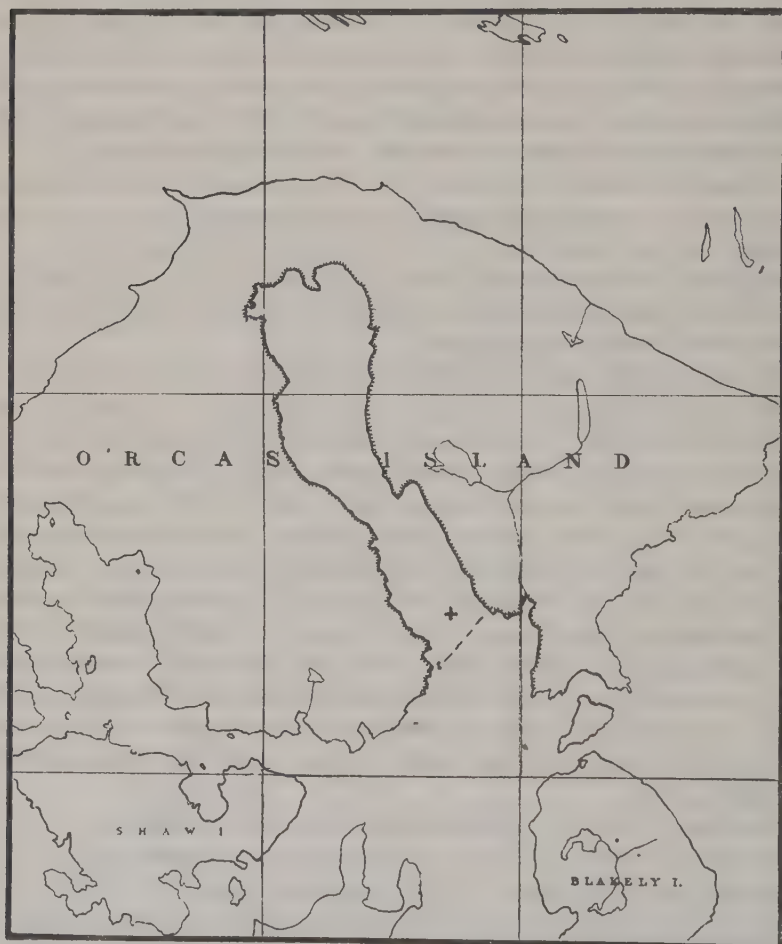


Fig. 2. Map of East Sound and Adjacent region. Cross marks sampling site.
Dashed line shows position of sill.

The sound is largely protected from winds and those occurring on sampling days blew toward the head, or obliquely, tending in that direction, rather than the reverse.

The population along the shores is small (perhaps 200) and mostly

resides at East Sound at the extreme head. There are no appreciable inflows of fresh water, and organic contamination from the land is very low at the sampling station.

Method of sampling.—Samples of 2–5 liters each were taken at the surface, and at 10 meters by means of an Ekman water-bottle. At the same time plankton tows were made at these depths for purposes of comparison. The samples were taken at intervals of about a week, beginning June 26th, 1931. All samples were taken at half tide, and when possible, on the ebb.

Immediately on reaching the surface, the samples were transferred into large, clean, stoppered bottles containing enough crystalline HgCl_2 to make a solution of 1:5000, so as to kill the organisms and prevent any change in the water.

Separation of the dissolved organic matter, net plankton, and nanoplankton.—In order to make separate determinations for the phytoplankton, nanoplankton, and dissolved matter, the sample was well shaken and a portion taken for determination without filtering. Another part was filtered through a standard No. 20 plankton net, and a portion of the filtrate determined. The rest of the net-filtrate was then passed through an N. Berkefeld candle, and the candle-filtrate determined.

The candle-filtrate gives the figure for dissolved matter directly. This subtracted from the net-filtrate figures gives the value for the nanoplankton (which pass the net but are held back by the candle). And finally the figure for the net-filtrate is subtracted from that for the natural water to get the value for the phytoplankton. Thus the protocol for 7/21/31 reads:

natural water	net filtrate	candle filtrate
9.60	8.85	9.15

with the result:

net plankton	nanoplankton	dissolved
.75	.70	8.15

(The figures are corrected to read in mg. per liter of water.)

Discussion of the results.—The results of the determinations, in mg. O_2 per liter, are shown in Table I, and from this the graphs (Figs. 3, 4, 5, and 6) were plotted.

TABLE I

DATE		PARTICULATE MATTER			DISSOLVED MATTER
		NET PL.	NANNOPL.	TOTAL	
6/26/31.	Surface	1.80	3.50	5.30	4.40
	10 m.	.65	.60	1.25	7.40
7/1/31.	Surface	.50	1.30	1.80	6.80
	10 m.	.30	.65	.95	5.10
7/8/31.	Surface	1.95	1.15	3.10	7.75
	10 m.	.50	.15	.65	6.25
7/16/31.	Surface	.95	.95	1.90	7.90
	10 m.	.90	1.15	2.05	4.95
7/21/31.	Surface	.75	.70	1.45	8.15
	10 m.	.25	.15	.40	6.60
7/30/31.	Surface	1.85	.40	2.25	7.15
	10 m.	.70	.25	.95	6.00
8/5/31.	Surface	1.15	.95	2.10	6.05
	10 m.	.25	1.30	1.55	4.70
8/13/31.	Surface	2.00	.50	2.50	6.95
	10 m.	.25	1.70	1.95	4.05
8/20/31.	Surface	1.20	1.25	2.45	7.15
	10 m.	1.15	.20	1.35	5.85
Average.....		.95	.94	1.89	6.29
		11.6%	11.5%	23.1%	76.9%
Average surface particulate matter.....				2.54	
Average 10 meter particulate matter.....				.55	
Average surface dissolved matter.....				6.92	
Average 10 meter dissolved matter.....				5.66	

All figures in mg O₂ per liter required for oxidation.

Upper figure = surface, lower figure = 10 meters, for each date.

It will be seen that in every case but the first surface sample, the dissolved matter considerably outweighs the particulate, but the average ratio is about 3.3:1 and hence lower than the average of Gran's determinations (8.3:1) and much lower than Pütter's, whose lowest figure is 65:1.

In the process tow-netting, during the taking of the samples it soon became evident that very little change was occurring in the quantity of plankton, either plant or animal. This led to the interpretation that there was a slow but constant out-flow of surface water from East Sound, and apparently a constant upwelling of the deeper waters at its head. The Sound is of such a length (about 7.5 statute miles)

and the water progresses at such a rate as to keep the upper level of water in a relatively constant condition during the period of summer weather.

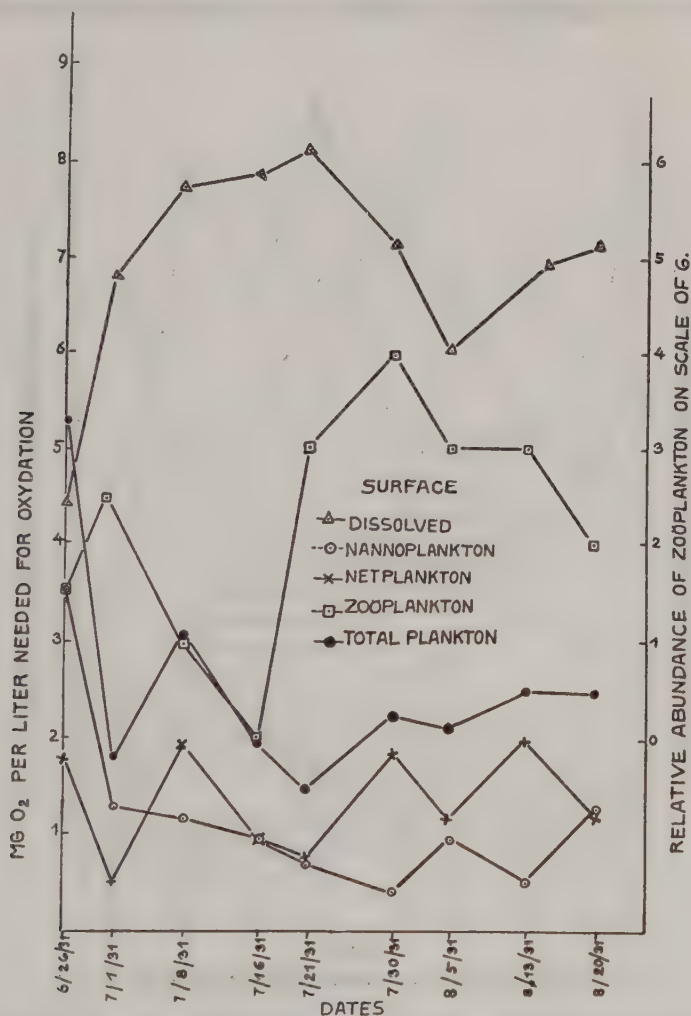


Fig. 3. Findings for samples taken at the Surface.

In other words, the conditions found by Fish were not being realized in the particular body of water chosen. Instead, the samples

at the station investigated all represent the conditions found by Fish just after a phytoplankton maximum. A few samples taken the first day (with the Laboratory boat) at stations nearer the head of the Sound show a slightly lower quantity of net-plankton (as determined

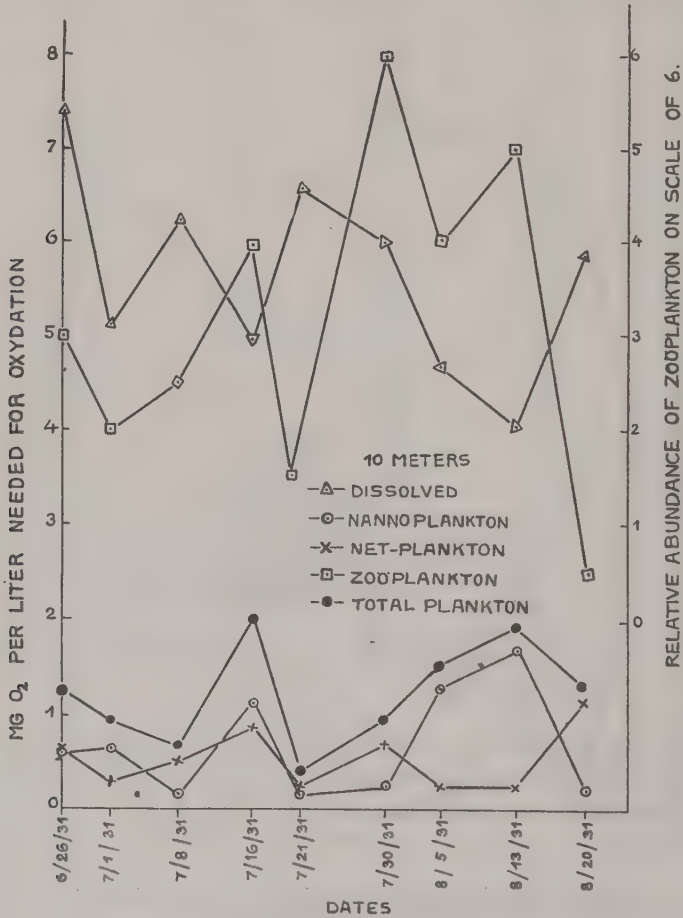


Fig. 4. Findings for samples taken at 10 meters.

chemically) than the regular sampling station (.96 mg. O₂ per liter as compared with 1.22 for the same day, averages of surface and 10 meters); a much lower quantity of nannoplankton (less than 1 to 4.3). Net tows taken at a later date in the open water out from the mouth

of the Sound showed zooplankton counts of 15-20 as against less than 6.

It must be pointed out here that the zooplankton in all the analyzed samples was, compared to the diatoms, extremely scarce. As no

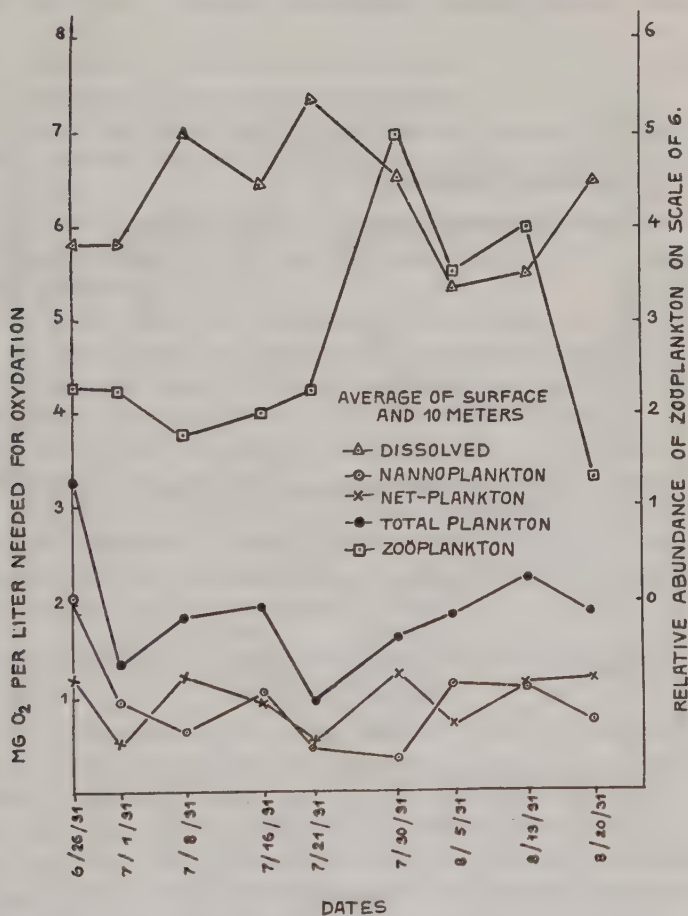


Fig. 5. Average of samples from the surface and from 10 meters.

method was available for making a direct comparison of the zooplankton with the phytoplankton, a purely arbitrary scale of 6 divisions was chosen to represent on the graphs the direction of variation of the zooplankton abundance during the sampling. The question

as to which division of the scale the sample belonged was decided upon by a comparison of net tows. Undoubtedly some of the variation found is a result of the vertical migration of much of the zoo-

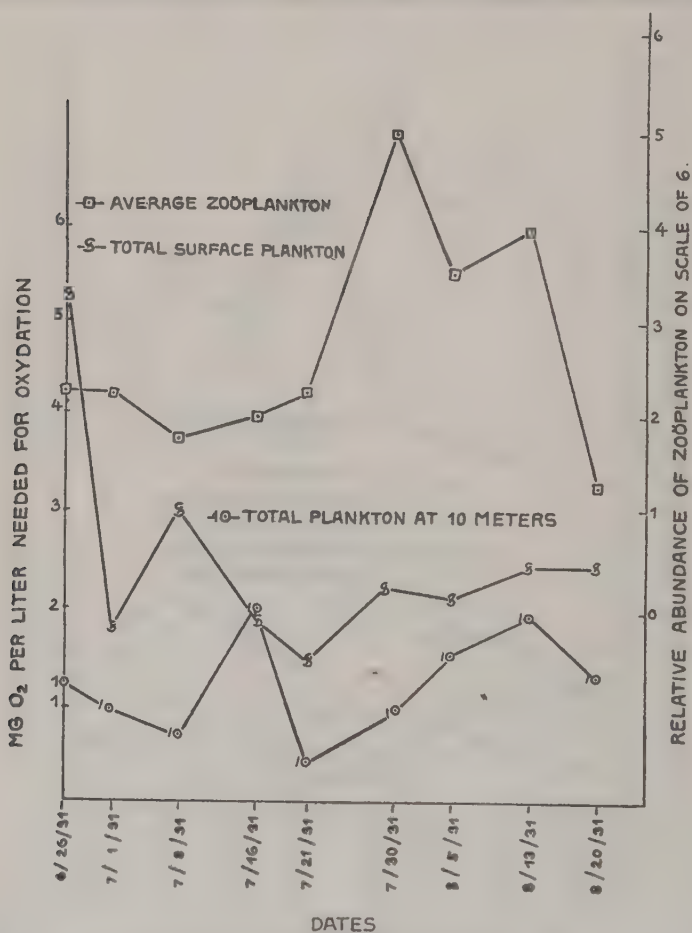


Fig. 6. Average abundance of zooplankton compared with the total net and nanoplankton at the surface and at 10 meters. This comparison was made because the zooplankton migrates vertically during the day, and may feed at the surface, or below, or both.

plankton. They are found considerably nearer the surface on dull days than on bright days. Finally it must be emphasized that the variations in zooplankton dealt with in my graphs are much less than

those appearing on Fish's. My whole scale from 1-6 would be included between his "very scarce" and "scarce."

Summary.—The quantitative determination of the nannoplankton between a phytoplankton and a zooplankton maximum was never achieved, but other results of considerable interest accrued none the less.

(a) A reasonably effective modification of the permanganate method was found for application to sea water.

(b) It was found that the dissolved organic matter averaged, for the period studied, 76.9% of the whole organic matter in the sea water.

(c) That the particulate 23.1% of the organic matter present was (at the phase studied) about equally divided between phytoplankton and nannoplankton.

(d) And finally some slight indication of the absolute quantity of organic matter present in the various forms was obtained. That is to say, the figures given probably represent the combustion of less than the total, but at least $\frac{1}{3}$ of the organic carbon present.

It can be seen that the organic content of sea water is lower than Pütter believed, but probably much higher than the estimates of Moore, Edie, Whitley and Dakin. It is probable that the nature of the dissolved organic substances in the sea is such that they cannot be readily assimilated by the zooplankton, but a possibility still exists that some forms may be able to use them.

SOURCES OF THE PARTICULATE FOOD SUPPLY IN NATURAL WATERS.

Types of particulate food.—As we have seen, there appears to be at least three times as much organic dissolved as particulate matter in the coastal waters of Norway and also in the waters of the State of Washington. But, as was pointed out (especially by Krogh), it is very unlikely that any appreciable portion of this residual dissolved organic matter is suitable for rapid assimilation, even by bacteria.

Therefore it seems proper to consider the knowledge of the particulate food (some data on which was included in the last chapter). Part of this subject is well covered by Krogh. He shows the fallacies of Pütter's figures and reasoning, especially from the point of view of the amount of water a zooplankt would have to filter to obtain enough phytoplankts for its food.

Krogh has, however, quoted comparatively little data on the nannoplankton, and has perhaps insufficiently stressed Lohmann's suggestion: That the rapidity of reproduction of a given food organism is as important as its numbers at any given moment.

The nannoplankton.—Plankton not taken in tows with the standard No. 20 net is classed as nannoplankton. Properly this term applies to forms too small to be held back, but such plankts as holotrich ciliates which are so delicate (even though large) that they are destroyed, and even certain naked peridineans, may for practical purposes be considered as nannoplankts.

The first person fully to recognize the possible value of the nannoplankton as food was Lohmann (1908 et seq.). The role of the nannoplankton in the sea has not as yet, I believe, been better summarized than by him (1911) when he says in substance: that although the total mass of the nannoplankton is small as compared with other forms of food, and that though it has been attempted in consequence to show that the nannoplankton is unimportant as a food source, this is not actually so. How much is in the water at a given time is important, but of equal importance is the rapidity of reproduction. The bacteria divide every half hour or so, the protozoa and protophyta every 1-5 days, while the metazoa take months to reproduce and grow. So that a given quantity of metazoa; and perhaps a fiftieth as much of protophyta and protozoa; and perhaps a three-hundredth as much of bacteria would all produce, in a given time, equal amounts of living substance. Aside from the rapidity of reproduction, Lohmann suggests that the nannoplankton is perhaps more easily eaten than, say, the large diatoms—an idea similar to that of Fish.

Bacteria.—Pütter (1924b) reaches an estimate of a million bacteria per cc. in sea water. This is perhaps too large a number for non-coastal waters, but it is hard to say without accurate figures. Many estimates of the number of bacteria in sea water have been made, but they are all inconclusive. Lohmann (1911) says: "Till now no one has succeeded in centrifuging the Bacteria perfectly . . ." The only other method of which extensive use has been made is plating out on fish-gelatine, or on other solid media. B. Fischer (1894) was the first to make much of the method, and the most recent that has come to my attention is Lloyd (1930). It is generally recognized, however, that this method is extremely unsatisfactory. It can be

expected to show pretty well the count for those bacteria that can grow on the particular medium used, but what part of the total this may be there is no way of knowing. Föyn and Gran (1928) say that the counts are so small in comparison with the relatively rich plankton, that one is forced to suspect that other forms are present that do not grow on the fish-gelatine. So far there has been no technique developed which can give any definite and true idea of the importance of bacteria in the sea as a source of food. Nothing more can be said than that sea water contains a great many bacteria. And that (from experiments to be described), at least some of them can be utilized as food by some organisms.

Phytonannoplankton.—Unfortunately little work has been done on nannoplankton life-histories, or indeed, on any phase of the nannoplankton. Though some counts and descriptions of species have been made, they have mostly been partial and of little ecological significance. (Cf. Gran (1912), Kolkwitz (1911), Krogh (1930a), Pascher (1912), Schiller (1914, 1925, etc.)). The literature is well treated in Krogh's paper.

ACTUAL AND RELATIVE QUANTITIES OF DISSOLVED ORGANIC MATTER, NANNOPLANKTON AND NET PLANKTON.

Since the determinations of the actual quantity of organic matter in the marine phytoplankton and nannoplankton are as rare and as untrustworthy as determinations of the dissolved organic matter, a comparison of their possible nutrient values is extremely hard to make. Beside my own results for East Sound, I know only of the estimations of Moore, Edie, Whitley, and Dakin (1912a). In order to extend this list, the indirect estimates of Pütter (1925) may be considered.

The earlier workers generally underestimated the marine phytoplankton, and it is largely to these authors that Pütter turned for his figures. In his 1925 work he takes his figures from a paper of Lohmann's published in 1908. Along with these he gives figures for the oxygen consumption of the copepods present in the water at the same season. I summarize his data in Table II. To obtain these figures he turns to his own 1923 paper (adversely criticized by Krogh) on the O_2 requirements for copepods, and for the numbers present at a given time in a given volume of water, he refers to the papers of Brandt who worked from 1888 to 1893. To simplify matters Pütter reduces all

the genera to "equivalent" numbers of *Oithona*, though as he uses a conversion factor based on differing surface areas instead of on the volume the exactness of the figures has been questioned.

Although direct quantitative values for the oxygen capacity of the marine plankton are extremely rare, several such determinations have been made for fresh water. Their application to marine conditions is apt to be misleading, but they are a useful check, and may be more dependable than Pütter's method of estimating volumes from counts and then estimating oxygen capacity from the estimated volumes.

Accordingly, to the table of Pütter's figures I add my own, those of Moore, Edie, Whitley and Dakin (1912a); and those of Krogh and Berg (1931) and of Birge and Juday (1922).⁵ (See Table II.)

TABLE II.

Month	O ₂ capacity of phytoplankton in 100 liters of sea water.	O ₂ capacity of nannoplankton in 100 liters of sea water.	Total in 100 liters.	O ₂ consumption of copepods in 100 liters of sea water, per day.
VII	3.69 mg O ₂	7.55	11.24	22.3
VIII	10.78 mg O ₂	5.70	16.48	18.8
IX	15.68 mg O ₂	2.14	17.82	17.2
XI	4.84	.88	5.72	1.18
XII	1.93	.27	2.20	.66
I	.68	.42	1.10	.62
Average	6.27	2.83	9.09	10.13
	95.	94.	189.	Bond*
	8.	34.	42.	M., E., W., and D.†
		567.		Birge and Juday‡
			2512.	Krogh and Berg§

* Average for summer months, East Sound, Orcas Island, State of Washington.

† Average for 6 determinations, season not given. Waters poor in plankton at the time. Sea off the Isle of Man.

‡ Average for late Spring and Summer, Lake Waubesa, Wisconsin.

§ Average through the year, Frederiksborg Schlosssee (fresh water).

It will be observed that for a good part of the year, according to Pütter's figures, there is more total phytoplankton than is needed by the copepods. But it must be admitted that if his figures are correct, a deficit would probably exist throughout the year, as (a) the zoo-

⁵ Unfortunately the oxygen capacity is not given in the two last named papers, but I use Pütter's method: i. e. the average for organic substances is 42% Carbon; the Oxygen capacity of 1 mg. of Carbon is 2.65 mg. O₂.

plankton does not eat all the phytoplankton, (b) the total mass of the phytoplankton is probably not useful as food, and (c) the generation time of the phytoplankton is probably so long that several times the theoretical minimum would have to be present to account for a large enough increment to serve as a food supply.

But, not only are Pütter's figures for the oxygen consumption of the copepods doubtful (Cf. Krogh 1931), but it will be seen that his figures for the phytoplankton are probably too low.

Of the direct observations, my own show an average of more than 8 times the total phytoplankton required by Pütter's copepods, at their maximum, while the figures of Moore, Edie, Whitley and Dakin (which because of their chemical method are almost certainly too low, and which were made when both the phytoplankton and zooplankton were at low ebb) show nearly twice the maximum requirement.⁶

If it be objected that these waters are not those containing Pütter's copepods, it may be remarked that these same copepods (Brandt's) were found far from the phytoplankton (Lohmann's) and moreover, that the copepods were dead 15 years before the phytoplankton came into being, so that any figures from temperate seas are quite in order.

Thus, while it is impossible to prove that the particulate matter in the sea does or does not constitute a sufficient food supply for the zooplankton, we can say that the phytoplankton figures given by Pütter are too low, and also that the particulate organic matter is actually nearly one third of the dissolved.⁷

For inferential figures, it may be noted that Allen (1919) found that Lohmann's centrifuge method (from which Pütter's figures are derived) is only about 3% efficient in showing the quantity of nannoplankton present. If, then, we take Pütter's figures for the nannoplankton and take this to be 3% of the nannoplankton actually present, we see that the Oxygen capacity of the nannoplankton at the lowest ebb is 9 mg. per 100 liters, or 251.6 mg. for the highest—in both cases more than 10 times his corresponding needs for the copepods.

⁷ Pütter, in his figures to show the amount of water an organism would have to filter in an hour to obtain its required food from the plankton, compared with the quantities of water from which it could obtain sufficient dissolved food, never reached so low a ratio. His figures in 1908 were 9400:55. Under criticism he revised them to 760:6, and later still to 65:1. Considering this "filtering argument" Moore, Edie, Whitley and Dakin (1912a) observe that planktonic animals do not swim about aimlessly with their mouths open but generally pursue their prey. Organisms in the sea are not distributed in an average manner. There are zones which are very rich and others that are poor in plankton. Copepods, pelagic fish, etc. are abundant at one spot and absent at others. By this means such creatures may find ample food in a region where the *average* amount is low.

EFFECTS OF DISSOLVED ORGANIC SUBSTANCES ON THE NANOPLANKTON AND PHYTOPLANKTON.

A possibility which is not much discussed in the literature, and which seems important to me, is that the primary dissolved organic substances freshly liberated into the sea (from decaying plants or other sources) may be utilized at once by the phytoplankton and nanoplankton.

a) EXPERIMENTS WITH CILIATES.

Kříženecký (1925a, 1925b), Ranson (1927), and others have referred to the findings of Peters (1920, 1921) and of Lwoff (1923), on the ability of the infusoria to live on dissolved foods as tending to support Pütter's theory.

My idea is that these results are equally strong evidence against Pütter's theory, or at least that they modify it very greatly. They simply introduce the possibility that a certain group of the nanoplankton may in part utilize certain dissolved substances and so make them available for larger, particulate-feeding forms. On the one hand they introduce a new source of rapidly multiplying particulate food, and on the other they may compete with the higher forms if these latter really do make use of dissolved substances in the sea.

The findings of Peters (1920, 1921) have been viewed with some suspicion and it is obvious that Peters' test for the presence of bacteria is entirely insufficient to prove total absence of contamination, and he himself comes to this conclusion (1926, 1927). It was, therefore, thought wise to repeat and amplify some of his experiments. Although the problem being investigated is mainly marine, a fresh water ciliate was chosen because a bacteria-free culture was obtainable, and because no marine ciliates were found which would live when freed from bacteria.

The general problem of the nutrition of the protozoa by dissolved foods has been so recently and so adequately treated by Oehler (1924b), Lwoff (1932), and by Luck, Sheets and Thomas (1931) that no résumé will be given here.

Material.—A pure (i. e. bacteria-free) culture of *Colpidium campylum* was obtained from Professor C. B. van Niel, of the Hopkins Marine Station, and I take this opportunity to express my great thanks for his helpfulness and advice in this work. The original isolation and the identification were made by Mr. W. A. Hetherington

of Stanford University, and the pure strain had been kept by Professor van Niel for some months.

It is necessary here to explain the purity of the cultures, especially in the light of Peters' (1921) paper, in which he has an apparently pure strain of *C. colpoda*. In dealing with a strain of non-parasitic protozoa grown at room temperature two considerations must be kept in mind: (1) Contaminants are likely to belong to the group of "water bacteria" which grow slowly, and which are arrested or killed by a temperature of 37° C. And (2) an active culture of stomate ciliates may feed so rapidly upon contaminating organisms that the latter may be kept down to very small numbers and be entirely missed in direct microscopic examinations of the culture.

Accordingly, it is necessary to keep test plates at low temperatures and for a comparatively long time, and in the case of tests in liquid media, it is necessary to get rid of the protozoa. This was most easily accomplished in the case of *C. campylum* by inoculating some of the culture into the same medium in a glass-stoppered bottle which was entirely full. The oxygen being shut off, the protozoa died in 24-48 hours, when air could be readmitted, and any bacteria present allowed to grow. A common contaminant of my cultures was a very small, motile rod which corresponded exactly to Peters' description of the "detached cilia" in his cultures. These grew badly on agar, but very well (though slowly) in liquid media under the above circumstances.

The medium used for the laboratory cultures of *C. campylum* was a 1:10 dilution of yeast autolysate with 2% of dextrose added, and 2% of CaCO₃ which served to prevent the pH from dropping to a lethal level. Cultures in this medium kept at 25° C. continued healthy for a period of at least two months. Growth without the dextrose was less heavy, and the cultures died sooner. With the dextrose and without the CaCO₃, the initial growth was excellent, but the pH dropped to 5 or lower, and the culture died out in two weeks or less.

Growth in yeast autolysate. Yeast autolysate was made up in dilutions with water in the following proportions: 1:9, 1:49, 1:99, 1:199, 1:399, 1:799. Five 250 cc. flasks were made up of each dilution, each flask containing 150 cc. of medium. On sterilizing (10 minutes at 120° C.) the lower dilutions tended to precipitate. This tendency was largely overcome by the addition of .05% NaCl. The sterile

flasks were inoculated by means of Pasteur pipettes with approximately .1-.2 cc. of a rich culture in yeast autolysate + dextrose. Such a culture contains over 200,000 organisms per cc., and on the basis of the rest of the work, this means that the inocula lay somewhere between .003 and .0003 cc. of centrifuged *Colpidium* per 100 cc., probably a little nearer the former figure than the latter. Inoculating from a counted culture with a measuring pipette was attempted but contaminations were so frequent that the method was abandoned. Therefore, the figures for rate of growth are to that extent unreliable.

The flasks were put in an incubator at 25° C. Each 24 hours one flask of each strength was removed from the incubator, and a sample taken. Part of the sample was examined for bacteria microscopically, and part was plated out on 1:20 yeast autolysate agar. The plates were kept at 25° for several days, and counts which had been made from flasks showing contaminations were, of course, rejected.

To the remainder of the flask 2 cc. of formol was added, and a sample, well shaken, and stained with iodine, was put in a counting chamber. The chamber was circular, 1 cm. in diameter and 1 mm. deep, and an ocular grid, giving an area of 1 mm². was used. The contents of 10 mm³. were counted and averaged. One hundred cc. of the remainder of the medium was centrifuged under constant conditions, and the volume of protozoa per 100 cc. of liquid recorded. This method was more important to me than the count (for the size of the animals varies with the age of the cultures, density of population, etc.), since it was desired to know the food values of the protozoa for larger forms rather than their number.

Unfortunately the lower dilutions produced so few animals during the first days that volumetric determinations could not be made with the centrifuge tubes at hand, and it was therefore necessary to approximate the volumes from the counts in some cases.

As a further indication of the food value of the ciliates, a liter of rich culture was killed with formalin and centrifuged, giving 1.5 cc. of *Colpidium*. This material was washed and dried at 65° C. to apparent dryness and then dried over concentrated H₂SO₄ to a constant weight of 99.45 mg., or 66.30 mg. per cc. (Since 1 cc. of centrifuged *Colpidium* contains about 35,000,000 animals, the individual dry weight is about .000002 mg.) From these values the dry weight column in the table was calculated.

All the data obtained are shown in Table III, and from these values

TABLE III.

Colpidium campylum. Grown in various dilutions of yeast autolysate. Data from cell counts, centrifuging, weighing, etc. All cultures 150 cc. medium in erlenmeyer flasks. Medium sterilized by autoclaving at 20 lbs. and 120° C. for 10 minutes.

Parts yeast auto-lysate.	Parts water.	Approximate % of Nitrogen.	Approximate % Protein Equivalent.	Number of cells per cubic millimeter.				Volume in cc. of <i>Colpidium</i> per 100 cc. of medium.				Dry weight (in mg.) of <i>Colpidium</i> per 100 cc. of medium.			
				1st day	2nd day	3rd day	4th day	1st day	2nd day	3rd day	4th day	1st day	2nd day	3rd day	4th day
1	9	.1	.6	58	156	146	188	.1	.42	.58	.61	6.6	27.9	38.5	40.5
1	49	.02	.12	24	115	96	—	.05	.22	.23	.2	3.3	14.6	15.3	—
1	99	.01	.06	20	73	27	—	.03	.14	.14	.1	1.9	9.3	9.3	—
1	199	.005	.03	1.6	2.7	20.8	24.1	(.004)	(.006)	.051	.055	—	—	3.4	3.7
1	399	.0025	.015	.25	.85	5.7	1.4	(.001)	(.003)	.02	.015	—	—	1.3	1.0
1	799	.00125	.0075	.04	.30	.05	.09	—	—	—	—	—	—	—	—

Parts yeast auto-lysate.	Parts water.	Approximate % of Nitrogen.	Approximate % Protein Equivalent.	Mean generation time, from start of curve to peak (in days).*		Generation time, 1st day (in days).*		Generation time, 2d day (in days).		Minimum generation time for a single day (in days).*		cc's of medium containing approx. 1 gm. Protein equivalent.		Dry wt. (in gm.) of <i>Colpidium</i> produced by 1 gm. Pr. eq.	
1	9	.1	.6	.36—	.52	.12—	.20	.48	.12—	.20	.166.7	.07	.13	.15	.12
1	49	.02	.12	.31—	.48	.14—	.25	.47	.14—	.25	833.3	.13	.15	.12	.04
1	99	.01	.06	.23—	.36	.15—	.30	.45	.15—	.30	1666.7	.12	.12	.04	—
1	199	.005	.03	.53—	.95	.27—	2.41	1.79	.32	.36	3333.3	.12	.04	—	—
1	399	.0025	.015	.71—	1.1	—	—	—	.36	—	6666.7	.04	—	—	—
1	799	.00125	.0075	—	—	—	—	—	—	—	13333.3	—	—	—	—

* First figure taking .0003 cc. *Colpidium* as starting point. Second figure taking .003 cc. as inoculum. (See text.)

the curves shown in Figs. 7, 8, 9, 10 and 11 have been drawn. The curves are largely self-explanatory, but notes complete the explanations.

There are several points of interest about the curves. In the first place, in the higher concentrations there is no lag phase, the rate of multiplication always being most rapid on the first day. Even in the lower concentrations, the lag phase is neither marked nor long, and this is the more remarkable, as the change in medium is great. The

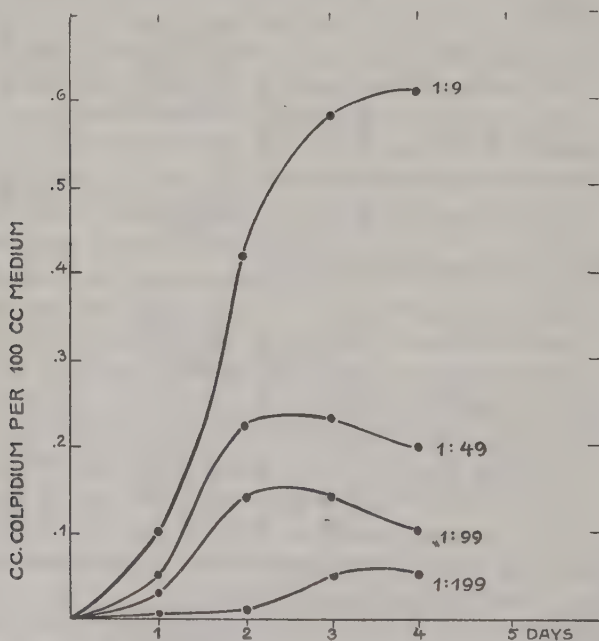


Fig. 7. Growth curves for *Colpidium campylum* in various dilutions of yeast autolysate.

curves all reach their highest point by the fourth day. The difference in time of the appearance of the apex may be caused in part by the long interval between counts. It is possible that with an interval of, say, 6 hours, instead of 24, the curves would appear even more similar. After the apex, all the curves appear to drop slowly and somewhat irregularly for a considerable period, depending on the strength of the medium, and in a flask of the 1:9 medium, a few animals were noted after more than three months. The counts and measurements

were made on the fifth day, but the increasing number of dead animals, which seemed gradually to disintegrate through autolysis made the values of such doubtful significance that the work was not recorded.

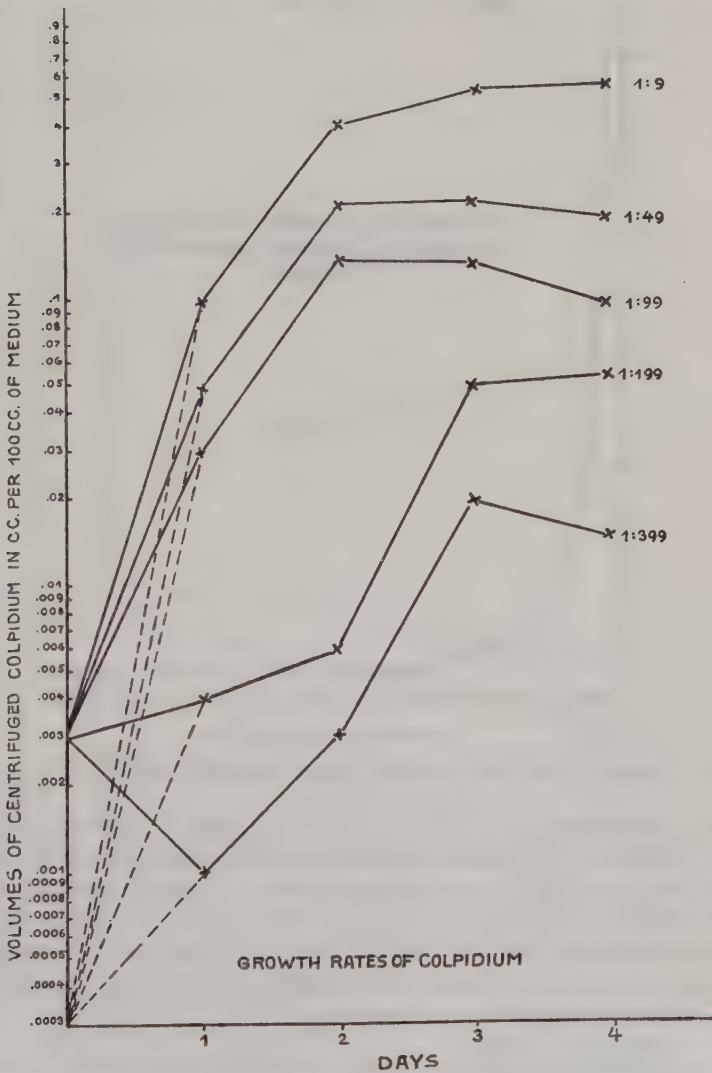


Fig. 8. Growth rates of *C. campylum* plotted on semi-logarithmic paper. The dotted lines represent rates for the first day assuming that the inoculum contained .0003 cc. *Colpidium*.

In fact, the growth rates in strengths above 1:99 are probably somewhat inaccurate, as shown by the upper curve in Fig. 10.

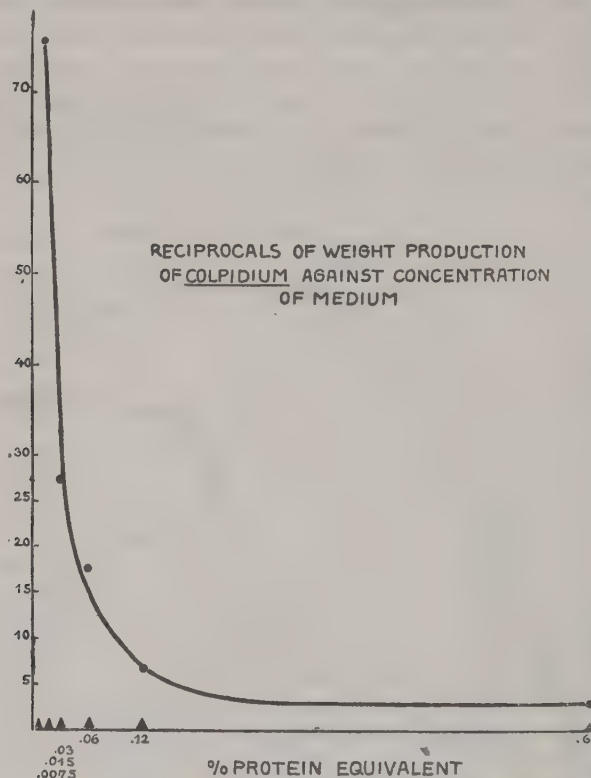


Fig. 9. The form of this curve is used to check the general form of the curves in Fig. 10.

Food requirements. Nitrogen.—Peters (1921) working with *C. colpoda*, found that it made ready use of NH_4 as a Nitrogen source. Since that time (1927) he has been unable to obtain growth on any liquid medium. From this, he concludes that his earlier cultures were contaminated with bacteria. None the less, his 1921 procedure was kept in mind, and some of his inorganic media were tested.

The following solution was made up:

MgSO ₄	.01%
K ₂ HPO ₄	.05%
Dextrose	.5 %
Maltose	.5 %

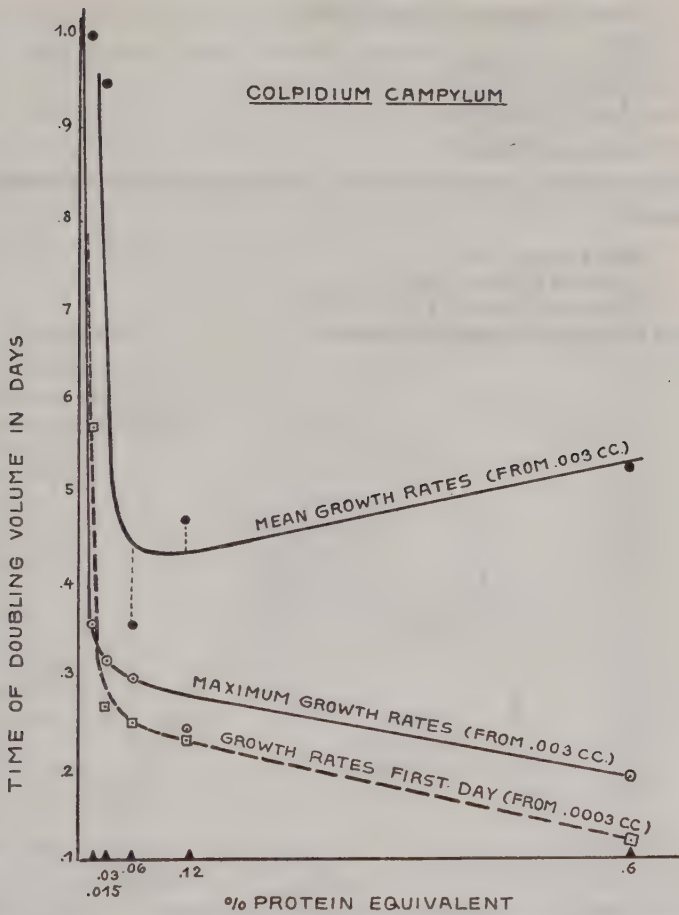


Fig. 10. Growth rates plotted against concentration of medium. See text for a discussion of the irregularities of these curves.

and to 10 cc. of this .05% of a single nitrogenous substance was added, the tube sterilized, and inoculated with *C. campylum*. The following nitrogen sources were tested:

Ammonium chloride
 Methylamine hydrochloride
 Dimethylamine hydrochloride
 Trimethylamine hydrochloride
 Ethylamine hydrochloride
 Diethylamine hydrochloride

Triethylamine hydrochloride
 Urea
 Asparagine (.5%)
 Tyrosine (.5%)
 Sodium nitrite
 Sodium nitrate

Made up in water, without added salts or sugars, the following were also tested:

Beef extract .5%
 Peptone (Bacto).5%
 Yeast autolysate 1:20
 A trypsin digest of *Artemia*

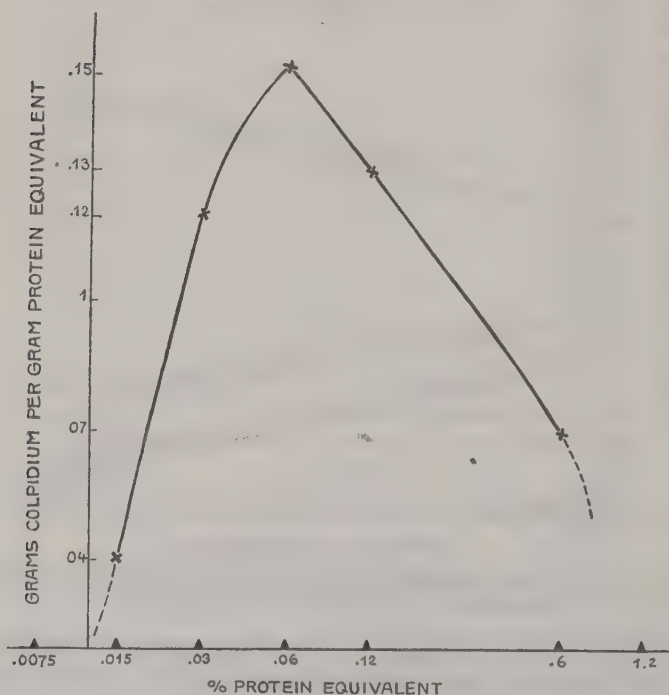


Fig. 11. Graph showing the efficiency of *Colpidium* in using food from different concentrations. Since the "grams protein equivalent" is only approximate, the figures along the Y-axis may have to be multiplied by a small common multiple to obtain the true values.

The results are given in Table IV. It will be seen that only when the nitrogen was in complex organic combination was any growth obtained. These findings are contrary to both of Peters' papers, as

in the one case he got growth on very simple nitrogenous sources, and in the other he was forced to feed particulate food (autoclaved yeast cells). The experiment was repeated three times with the same results, except that a light growth was obtained in one case with trimethylamine hydrochloride. This could not be repeated, nor could subcultures be made in this medium. It seems probable, therefore, that an unduly large inoculum afforded enough yeast autolysate to produce some growth.

TABLE IV.

(- - = no growth; lg = light growth; fg = fair growth; hg = heavy growth.)

N SOURCE	FORMULA	% USED	RESULTS
Ammonium chloride.....	NH_4Cl	.05%	- -
Methylamine hydrochloride..	$\text{CH}_3\text{NH}_2\text{HCl}$	.05%	- -
Dimethylamine " ..	$(\text{CH}_3)_2\text{NH}\text{HCl}$	.05%	- -
Trimethylamine " ..	$(\text{CH}_3)_3\text{N}\text{HCl}$	.05%	- -
Ethylamine " ..	$\text{C}_2\text{H}_5\text{NH}_2\text{HCl}$	.05%	- -
Diethylamine " ..	$(\text{C}_2\text{H}_5)_2\text{NH}\text{HCl}$	.05%	- -
Triethylamine " ..	$(\text{C}_2\text{H}_5)_3\text{N}\text{HCl}$	.05%	- -
Urea.....	$\text{NH}_2\text{CO}\text{NH}_2$	.05%	- -
Asparagine.....	$\text{CO}_2\text{H}\text{CH}(\text{NH}_2)\text{CH}_2\text{CO}\text{NH}_2$...	.5%	- -
Tyrosine.....	$\text{OH}\text{C}_6\text{H}_4\text{CH}_2\text{CH}(\text{NH}_2)\text{CO}_2\text{H}$..	.5%	- -
Sodium nitrite.....	NaNO_2	.05%	- -
Sodium nitrate.....	NaNO_3	.05%	- -
Beef extract.....	All contain comparable amounts of organic Nitrogen. }	.5%	hg
Peptone.....		.5%	fg
Yeast autolysate.....		1:20	hg
Artemia digest (trypsin).....		1:20	lg

Food requirements. Carbon.—At the same time with the above experiments, a number of solutions were made containing .05% of NH_4NO_3 , and a variety of carbon compounds. Growth occurred only in tubes containing dextrin. This substance is difficult to purify, and almost always contains some proteinaceous matter, and in the light of the previous experiments, such an impurity seems the most probable explanation of the observed growth.

It was still considered quite likely that carbon compounds might be utilized from solution by *Colpidium*, especially because the yeast autolysate dextrose medium was so obviously superior to yeast autolysate alone. Accordingly the whole series was repeated with solutions which contained 1:100 yeast autolysate as the nitrogen source, and the growth was compared with that in tubes containing

TABLE V.

(-- = no growth, or less than in yeast autolysate alone, or equal to yeast autolysate alone; lg = slightly more growth than in yeast autolysate alone; fg = considerably more growth; hg = much more.)

C SOURCE	FORMULA	TYPE OF COMPOUND	% USED	RESULTS
Ethyl alcohol.....	C_2H_5OH	monohydric alcohol.....	1. %	lg
Glycerine.....	$HO.CH_2.CH.OH.CH_2.OH$	trihydric alcohol.....	1. %	lg
Mannitol.....	$C_6H_{12}(OH)_6$	hexahydric alcohol.....	1. %	fg
Acetaldehyde.....	CH_3CHO		.01 %	--
Sodium acetate.....	$NaC_2H_3O_2$	(salt of) monobasic fatty acid.....	1. %	hg
Sodium glycollate.....	$NaC_2H_3O_3$	(salt of) monohydroxy fatty acid.....	1. %	fg
Sodium lactate.....	$NaC_3H_5O_3$	(salt of) monohydroxy fatty acid.....	1. %	fg
Sodium pyruvate.....	$NaC_3H_3O_3$	(salt of) monobasic ketonic acid.....	1. %	hg
Sodium succinate.....	$Na_2C_4H_4O_4$	(salt of) saturated dibasic acid.....	1. %	--
Sodium malate.....	$Na_2C_4H_4O_5$	(salt of) hydroxy dibasic acid.....	1. %	--
Sodium tartrate.....	$Na_2C_4H_4O_6$	(salt of) dihydroxy dibasic acid.....	1. %	hg
Sodium citrate.....	$Na_3C_6H_5O_7$	(salt of) hydroxy tribasic acid.....	1. %	--
Dihydroxyacetone.....	$CO(CH_2OH)_2$	ketone.....	1. %	--*
Dextrose.....	$C_6H_{12}O_6$	aldohexose.....	1. %	hg
Laevulose.....	$C_6H_{12}O_6$	aldoketose.....	1. %	hg
Galactose.....	$C_6H_{12}O_6$	aldohexose.....	1. %	lg
Sucrose.....	$C_{12}H_{22}O_{11}$	disaccharose.....	1. %	fg
Maltose.....	$C_{12}H_{22}O_{11}$	disaccharose.....	1. %	hg
Lactose.....	$C_{12}H_{22}O_{11}$	disaccharose.....	1. %	fg
Xylose.....	$C_5H_{10}O_5$	pentose.....	1. %	hg
Dextrin.....	$(C_6H_{10}O_5)_x$	polysaccharose.....	1. %	fg
Inulin.....	$(C_6H_{10}O_5)_6$	polysaccharose.....	1. %	fg†
Glycogen.....	$(C_6H_{10}O_5)_x$	polysaccharose.....	1. %	fg
Starch.....	$(C_6H_{10}O_5)_x$	polysaccharose.....	1. %	hg
Salicin.....	$(C_{13}H_{19}O_2(OH))_6$	glucoside.....	1. %	fg

* Dihydroxyacetone is partly destroyed by the heat of sterilization (120° C. for 10 minutes) and substances toxic to Colpidium may be produced.

† Probably impure (Cf. text).

1:100 yeast autolysate only, which in this dilution gives a slight, but perfectly definite growth. The results are shown in Table V. The growth in sugars and their oxydation products, and the oxydation products of fats can be seen to be especially good.

Further to check Peters' 1921 results, attempts were made to grow the organism on his ammonium glycono-phosphate medium. In no case was growth obtained which could be continued in subcultures unless the tube in question was contaminated.

Discussion.—Lwoff (1924) has shown that *Glaucoma piriformis* can utilize Witte's peptone, or peptone from casein, but not peptones from silk, fibrin, nor gelatine, nor even a mixture of the three, though such a mixture contains all the amino acids that have been found in Witte's and casein peptones. These experiments were not repeated on *Colpidium*, but the organisms are similar in that only highly complex sources of nitrogen prove suitable. There is no evidence that the animals in question have any power to synthesize from single amino acids or from other simple substances, the necessary materials for growth and continued existence.

Lwoff (1923) with "*Colpidium colpoda*," failed to get growth on Peters' inorganic media, but succeeded with organic nutrient solutions. He found subsequently that he had mis-identified the form, and was dealing with *Glaucoma piriformis*.

This possibility also arises in the case of *C. campylum*, for Oehler (who originally (1920) reported entire failure to grow *C. colpoda* on dissolved food), found out later (1924a) that he had been dealing with *C. campylum*, and hence that it was this latter form which required particulate foods. He strongly criticized Peters' 1921 technique, and believed (1924b)—apparently without having seen Lwoff's papers—that no stomate ciliate had been shown to be capable of subsisting on dissolved food alone.

However, there appears to be no doubt that the strain of *Colpidium campylum* used by me grows extremely well on dissolved foods, though a complex nitrogen source is necessary. In nature, in forms with like food requirements, it seems possible that a certain part of the utilized food may be taken in a dissolved state.

According to figures given by Birge and Juday (1927), and following their method of computation, it is seen that in Lake Mary, Wisconsin, there were on one date of sampling about .0082% of "crude protein" and a .041% "carbohydrate." It will be seen that Lake Mary at

that time contained more nitrogenous matter than the 1:800 yeast autolysate medium, in addition to an appreciable amount of "carbohydrate." However, as the "crude protein" and "carbohydrate" of Birge and Juday are rather analytical conveniences than actual chemical compounds, it is difficult to say what portion of these would actually be usable as food by protozoa, and the quantities in question are close to non-usable dilutions in the case of the nitrogen source. Moreover, this water sample is unusually rich in dissolved matter, containing 2 or 3 times the average. As no experiments have been made to determine the usability of highly diluted carbohydrates, no direct statements as to their value in such waters as Lake Mary can be made. It may be reasoned, however, that as the "carbohydrate" averages about 3 times the "crude protein" in the lakes studied by Birge and Juday, and as a wider variety of carbon sources could be used in the experiments, there is more likelihood of some dissolved carbon source reaching a useful concentration, than there is of a dissolved nitrogen source providing food for the protozoa. At the same time, Lwoff and Roukelman (1929) have shown that *Glaucoma* performs extra-cellular digestion of peptones by the liberation of a trypsin into the medium, so that there is a possibility of a greater concentration of soluble nitrogen in the immediate neighborhood of the infusoria. What effect this might have on bacteria and detritus it is impossible to say.

It should be noted that the utilization of dissolved foods by the protozoa under natural conditions must involve a successful competition with the more rapidly dividing bacteria, and it may well be that under natural conditions the bacteria themselves would always be so much more important as a food source, that the effect of dissolved foods (even though suitable for direct use by the protozoa) would be largely secondary through the bacteria, and that the primary effect would have very little ecological significance.

Lwoff's recent (1932) monograph summarizes the previous work on *Glaucoma*, and also that on *Euglena gracilis*, and on various trypanosomes. Lwoff states in this paper that *Glaucoma piriformis* is the only stomate ciliate which has been found to grow in a purely liquid medium. This new paper does not add to the knowledge of *how dilute* a medium can be utilized, but it does add to the known variety of organic substances that can be made use of by certain protozoa in moderately concentrated solution.

During the summer of 1931, Mr. J. O. Thomas, of Stanford Uni-

versity, succeeded in isolating some 20 strains of fresh water protozoa in pure culture. These have not been fully identified by him as yet, but he informs me that there appear to be two or more species of *Glaucoma* and one or more species of *Colpidium*. With the more highly organized forms such as *Paramecium*, *Euplotes*, *Stentor*, etc. he had no success whatever. And in none of the newly isolated forms is growth so rapid and abundant as in the experimental strain of *Colpidium campylum*.

b) EXPERIMENTS ON ALGAE.

A further probable effect of dissolved substances in the sea may be found in the fact that the addition of as little as 1% yeast autolysate (the equivalent of 0.06% protein) to the medium containing the pure culture of *Dunaliella salina* increase the speed of multiplication greatly. Counts were not undertaken, but at the end of ten days when the organic-free tubes showed only a faint green ring, the tubes with the yeast autolysate were densely green throughout with actively swimming flagellates. Addition of 0.1% dextrose to the yeast autolysate tubes somewhat increased the effect.⁸

That this is a result of additions of very small amounts of organic substances is shown by the fact that 1:20 yeast autolysate with or without sugar did not give so much increased speed as the 1:100, and solutions of the same strength lacking the inorganic nutrients, while giving a very rich culture eventually, were as slow as the inorganic media or even slower than they.

At the same time that the food-requirement experiments were being conducted with *Colpidium*, similar experiments were undertaken with several algae. In the case of the green forms used, there appeared to be growth on practically all the nitrogen sources, and on practically all of the carbon sources tried. However, there was always the danger that active photosynthesis was going on, and as many of the flagellates lose their mobility in the dark and behave unusually in their habit of growth, the experiments with green forms were not

⁸ The stimulating effect of small quantities of organic matter added to pure cultures of various algae has been frequently remarked. Miquel (1890-93), O. Richter (1906, 1909, 1911), Jacobsen (1910), Beijerinck (1890, 1898, 1904b), and Mainx (1928) are especially interesting, and the latter (in his section on *Biologie der Algen* Tab. Biol., 1929) explains the bearing of organic foods on facultatively autotrophic algae. Gran (1931) shows the marked effect of organic compounds containing iron, such as soil extracts, on the growth of the phytoplankton.

continued very fully, and work was concentrated on *Prototheca zopfii*.

This alga is a colorless *Chlorella*. Since it is without pigment it is entirely dependent on ready-made nutriment. However, the work of Beijerinck (see bibl.), who originally isolated this strain, seems to show that its capabilities for using organic nutrients was exactly like those of the green *C. pyrenoidosa*, so that it was an admirable form for experimentation, in that the possible complication of photosynthesis was eliminated.

TABLE VI.

N SOURCE	<i>Prototheca zopfii</i>	<i>Polytoma wella</i>	<i>Chlamydomonas pulvinata</i>	<i>Lobomonas</i> sp.	<i>Dunaliella salina</i>
Ammonium chloride.....	fg	+	+		++
Methylamine hydrochloride.....	--	-	+		
Dimethylamine hydrochloride.....	--	-	+		
Trimethylamine hydrochloride.....	fg	-	+		
Ethylamine hydrochloride	fg	-	+		
Diethylamine hydrochloride	hg	-	+		
Triethylamine hydrochloride	fg	-	+		
Urea.....	fg	-	+		++
Asparagine.....	hg	-	+	+	
Tyrosine.....	hg	-	+	+	
Sodium nitrite.....	fg	-	+		
Sodium nitrate.....	--	+	+		
Beef extract.....	hg	+	+	+	++
Peptone.....	hg	+	-	+	+
Yeast autolysate.....	hg	+	+	+	++
<i>Artemia</i> digest.....	hg	+	+	+	++
C SOURCE					
Ethyl alcohol.....	hg	-			
Glycerine.....	hg	-			
Mannitol.....	fg	-			
Acetaldehyde.....	--	-			
Sodium acetate.....	hg	+			
Sodium glycollate.....	hg	-			
Sodium lactate.....	sg	+			
Sodium pyruvate.....	fg	+			
Sodium succinate.....	--	-			

All prepared as in the experiments on *Colpidium*, except that the so-

TABLE VI.—Cont.

C SOURCE	<i>Proto- theca zopfii</i>	<i>Polytoma uwella</i>	<i>Chlamy- domas pulvinata</i>	<i>Lobomonas sp.</i>	<i>Dunali- ella salina</i>
Sodium malate.....	—	—	lutions for <i>Dunaliella</i> had 5%		
Sodium tartrate.....	hg	+	NaCl added. All cultures free		
Sodium citrate.....	sg	—	from bacteria.		
Dihydroxyacetone.....	fg	—			
Dextrose.....	hg	+			
Laevulose.....	hg	+			
Galactose.....	fg	—			
Sucrose.....	hg	—			
Maltose.....	hg	—			
Lactose.....	hg	—			
Xylose.....	sg	+			
Dextrine.....	hg	—			
Inulin.....	fg	—			
Glycogen.....	fg	—			
Starch.....	hg	—			
Salicin.....	hg	—			

Key: hg = heavy growth, fg = fair growth, sg = slight growth, + = growth, ++ = better growth, — = no growth. Blank spaces = no experiment.

The results of the algae experiments are shown in Table VI. For *Prototheca* they are in accord with the less extensive work of Krüger (1894) and of Henneberg (1926). It will be observed that the utilization of carbon-containing substances corresponds roughly to that of *Colpidium*, but that there is a much wider utilization of nitrogen sources. This is, of course, generally true of plants.

In addition to the biochemical requirements of the protozoa, Lwoff, in his 1932 monograph, discusses the utilization of dissolved organic substances by such algae as *Chlamydomonas agloëformis*, *Haematococcus pluvialis*, and *Polytoma uwella* (non-photosynthetic). The autotrophic algae were tested in the dark as well as in the light, and—as I found in the algae studied by me—a wide variety of organic substances are assimilable from solution.

c) BACTERIA.

It seemed impractical to make investigations similar to the above on bacteria, as their omnivorousness is so well known. Certainly it can safely be stated that there is scarcely an organic compound known which (even in very great dilution) will not be attacked by

some form of bacteria. What versatility a given species lacks in its feeding ability is made up for by other forms which are everywhere present. That this generality holds good for the dissolved organic matter in the sea, as well as elsewhere, is vouched for by the bacterial method of Gran and Ruud for determining the dissolved organic content of sea water.

Summary.—Account has been taken of the living particulate food in the sea. From the experiments done it would appear that Lohmann's belief: that the speed of multiplication of the various forms is a very important factor in their value as food, is correct. It is also shown to be probable that dissolved organic substances increase the speed of reproduction of various of the phytoplankton and nanoplankton. This suggests that any correlation between increase in dissolved organic matter and increase in the zooplankton may well be indirect rather than direct.

THE PERMEABILITY OF AQUATIC ANIMALS

We have seen that while it is doubtful that the dissolved organic matter of sea water is very greatly in excess of the particulate, and while it is probably largely in the nature of relatively unassimilable compounds, there is still some possibility that it may prove useful to planktonic animals, especially in the early stages of organic decay.

But aside from the existence of such a possible food supply, it is necessary to consider whether or not zooplanktonic animals are permeable to dissolved substances. For, obviously, however much organic matter is present, it cannot be utilized as a food supply unless the organisms in question are capable of taking it into their systems.

Krogh (1931) is of the opinion that aquatic organisms in general are almost entirely impermeable. It therefore seems necessary to consider this matter at some length, both in its theoretical aspects and also on the basis of the experimental evidence at hand, giving especial attention to chitin-covered animals.

Krogh reached his conclusions largely as a result of experiments on a fresh water crayfish and on non-larval eels.⁹

⁹ Pryzylecki (1922) showed that fresh frog skin is permeable to a number of sugars, and to amino acids and other products of the breakdown of proteins. He also suspended live frogs, of which the anus was carefully blocked, in sugar solutions, with the mouth out of water. After a few hours he could demonstrate the substances in various parts of the body of the frog.

Chomkovic (1926) found that the fresh skin of a number of fish is permeable to

But the animals Krogh was considering were all of one physiological type in which such results were only to be expected.

Physiological groups of aquatic animals.—There appear to be in general two great physiological groups of aquatic animals: those in which the body fluid is very unlike the medium, and those in which the body fluid and medium are essentially similar. It is obvious that to the first group practically all fresh water organisms must belong. Not only are their body fluids very different in composition from natural fresh waters, but also in osmotic pressure. To this same group some marine organisms also belong, notably the teleosts, with a blood the osmotic pressure of which is much below that of sea water.

To the other group, with blood of composition and osmotic pressure not unlike the medium, belong practically all the marine invertebrates that have been investigated.¹⁰

It is obvious that if aquatic forms that are homoiosmotic (osmotic pressure of the blood independent of the medium) were found to be readily permeable both to water and to solutes, they must exemplify an extraordinary osmo-regulatory system, which would not be required of impermeable animals.

Experiment bears this out. Whereas the homoiosmotic animals have generally been found to be relatively impermeable, quite the contrary has been found for marine invertebrates.

Margaria (1931) and Hukuda (1932) using different methods, both found the crabs *Portunus puber*, *P. depurator*, *Carcinus maenus*, *Maia squinado* and *Cancer pagurus* to be permeable to the salts in sea water. Beadle (1931) found the same for *Nereis diversicolor*. Pantin (1931a, 1931b), Weil and Pantin (1931) and Beadle (1931) found that the flatworm, *Gunda ulvae*, was permeable to salts. There is some evidence in Beadle's paper that the site of permeability in *Gunda* is the gut. Schlieper (1929, 1930) also considers several of the above named forms to be permeable to salts.

One of the most interesting papers on the permeability of marine forms is that of Bethe (1930). He worked with organic substances as

glucose, sucrose, and peptone. Krízeneký (1925b) states that while living carp skin is permeable from without inwards to such substances, permeability in the reverse direction is not possible until the skin cells have died. Krogh denies the importance of these experiments because the penetration of the dissolved substances was so slow, and because he believes the solutions to have been so strong as to have an injurious effect upon the skins.

¹⁰ Also the hagfish, *Polistotrema stouti* (Bond, Cary and Hutchinson (1932)).

well as with electrolytes. He showed by blood analyses that the mollusc *Aplysia* was permeable to cane sugar, dextrose, glycerine, and urea; urea entering most readily and cane sugar least. *Sipunculus*, *Holothuria*, and "various medusae and pelagic molluscs" as well as *Carcinus maenas* seemed to act the same way, and all were readily permeable to salts.¹¹

In the case of the crustacea, most of the authors assume or imply that it is the gills that are permeable, but so far as I can learn, there is no proof that such is generally the case, and without experimental evidence it must be admitted that the gut may play at least part of the role.¹²

In a consideration of the utilization of dissolved foods, it is obvious that animals feeding from solutions will have a great advantage if the external surface is permeable rather than only the gut. In the latter case a vigorous stream of water through the alimentary canal would be needed to account for the absorption of as much food by the gut as by the integument if the permeabilities are of the same order.

The majority of the individuals of the zooplankton have no such gut-stream, and most of them have a chitinous covering. In this connection it is interesting to find Krogh's belief that chitin is very little permeable.

Permeability of chitin.—But Petrunkevitch (1900), in finding that "Der Kropf der Insecten (which is lined with chitin) ist das Hauptorgan der Absorbition," showed that chitin is readily permeable, at least to some organic substances. This work was confirmed by Sanford (1918). Eidmann (1922) working with chitin membranes (though only experimenting with electrolytes) concludes: "Dünne Chitinmembranen können, auch wenn sie keine Spur von Poren

¹¹ The above studies were made generally with electrolytes, but membranes which are permeable to these are, in general, permeable to non-electrolytes as well.

¹² There have been a number of experiments on lamellibranchs which show some permeability (especially to glucose). These are not considered at length as they appear to have little bearing on a study of the plankton. Yonge (1928), Ranson (1927), Galtsoff and Whipple (1930), and Spärck (1927) all used oysters. Churchill (1915, 1916), used fresh water mussels. Koller (1930) used *Mya*, *Mytilus* and *Cardium*. It appears that all these forms can absorb glucose from fairly strong solutions in the gut under ordinary circumstances, and directly in the mantle cavity when the animals are "bleeding" and the epithelium is covered with phagocytes. Yonge believes the absorption is by the phagocytes. Krogh thinks absorption through the injured epithelium more likely. The authors agree that the normal food of the bivalves is particulate.

aufweisen, für osmotische Vorgänge durchlassig sein." and not unnaturally, "Je dünner die Chitinhaut ist, desto grösser ist ihre Durchlassigkeit." So that naturally occurring chitin membranes cannot be regarded, simply because they are chitin, as being "semipermeable membranes" in the sense that they are impassable to anything but water.

Indeed, some permeability has been shown for the chitin integument of some of the homoiosmotic forms, Krogh himself (1930b) found *Daphnia pulex* to take up sugar from solution (though this may have taken place through the gut), although it always lost more dissolved matter than it took in.¹³ And the work of Fischel (1908) (Cf. also Gickelhorn 1931 etc.) showed a number of copepods, cladocera, etc. to be permeable to a variety of vital stains, some of which certainly penetrate the integument.

Koehring (1930, 1931) worked with neutral red extensively and found *Daphnia* to stain very readily, the course of staining being as follows; (neutral-red 1:2,000,000):

one fourth to 1 hour	lumen of the digestive tract.
"soon"	lumina of the hepatic caeca.
about two hours	phagocytic system cells.
2 hours	supporting cells of gonads.
4 hours	blood corpuscles, the cells of the digestive tract, etc.

She interprets these observations to mean that the neutral-red passes through the digestive cells without staining them and then returns to them from the body fluid. But it seems quite as possible that the stain reaches the body fluid through the integument.

Using 1:1,000,000 neutral-red, I found essentially the same order of staining with *Calanus finmarchicus* and also with *Euchaeta* sp., though in both cases the speed of staining was much greater, the blood corpuscles being stained in about 25 minutes with *Calanus* and in about 35 minutes with *Euchaeta*. A part of the difference is undoubtedly owing to the stronger concentration.

The permeability of Artemia; Vital stains.—Using neutral-red on *Artemia franciscana*,¹⁴ in sea water, the order was as follows:

¹³ The same was true for a fresh water mussel, *Dreissensia polymorpha*.

¹⁴ The *Artemia* used by me are at present in a somewhat doubtful taxonomical position. They were first described from the general region by Kellogg (1906), as *Artemia franciscana*. Heath (1924), who has described the external development very

- about 10 minutes lumen of stomach.
- about 15 minutes lumina of the hepatic caeca and lumen of gut
and digestive cells (including cells of caeca).
- about 25 minutes phagocytic system.
- about 1 hour blood corpuscles.

With congo red the sensory hairs and their basal cells on the ends of the antennules stained brilliantly. The branchiae were strongly stained by the methylene blue.

If the behavior of the stains, and the resistance of *Artemia* to certain poisons,¹⁵ are any guide to the use of possible food substances, it might safely be doubted that dissolved foods play any important role in the growth of these phyllopods. But this is scarcely a fair statement of the case. The stains used are not foods, nor of the nature of foods, and the results simply mean that the vital stains used penetrate the chitinous integuments in limited areas, if at all.

Electrolytes.—Medwedewa (1927) found that the osmotic pressure of the blood of *Artemia* was much less than that of the medium in which it lives. (Also reported by Thompson (1917) and by Martin and Wilbur (1921).) For this reason Schlieper (1930) assumes that it is relatively impermeable and like the teleosts in this respect. Pantin (1931b) falls in with this view, pointing out that *Artemia*, like the teleosts is probably descended from fresh water stock.

But while *Artemia* may be descended from fresh water ancestors, and certainly has blood with a much lower salt concentration than that of the medium, the just cited work of Martin and Wilbur suggests that the animals may be somewhat permeable. They show that *Artemia* put in a brine differing greatly from their accustomed medium, or into fresh water, may often succumb with considerable speed, and this could hardly be brought about except by the loss or uptake of salts, at least in some of the cases. The *Artemia* were especially

accurately, considered them to be *Artemia salina*, var. *principalis* Simon. The form is found in salt works and natural salterns along the shores of San Francisco and Monterey Bays.

¹⁵ Some experimental data of times till death:

Alcohol 25%	25 minutes—3 hours
Alcohol 95%	4—10 minutes
Bouin's solution	15 minutes—5 hours
4% Formaldehyde	30 minutes—8 hours
.5% " "	1 hour and 30 minutes—24 hours.

The variation in times corresponds partly to the number of *Artemia*.

susceptible to potassium salts. This is true even when the osmotic pressure of the two media is equal.

Boone and Baas-Becking (1931) consider *Artemia* to be impermeable except for the epithelium of the mid-gut, and they explain its long life in certain poisons by the belief that the gut can be hermetically closed in an unfavorable environment. But elsewhere in the paper they include a graph (based on the findings of Martin and Wilbur) which emphasizes the rapidity of the toxic effect of potassium salts, so that it might appear that potassium at least can penetrate the integument of the animal.

Professor Baas-Becking has personally suggested to me that in the living animal a great part of the water is in a "bound" state—probably in relation to hydrophil colloids—so that the water content of the extracted blood is no indication of the effective osmotic pressure inside the living animal, and that as the osmotic pressure of the medium increases, a larger portion of the internal water becomes "bound." If this be the true explanation of the animal's ability to live in concentrated brines, it appears to me that impermeability of the integument is not necessarily implied.

Gas absorption. Although there was no evidence that *Artemia* absorbed any of the vital stains through the integument in appreciable quantities, oxygen must be absorbed for respiration, probably constantly and fairly rapidly. This seemed especially certain when it was observed that in transporting the *Artemia* from the salterns to the laboratory, overcrowding, especially in a closed container, quickly resulted in heavy losses.

In an attempt to obtain more exact knowledge of the oxygen consumption of the animals, *Artemias* were put into brine through which CO_2 had been bubbled long enough to remove the oxygen. The *Artemias* were paralyzed in less than 30 seconds and could not be resuscitated after about two minutes. This was at first interpreted to be death from lack of oxygen which would seem to show that this gas is very rapidly and constantly absorbed from the medium. Subsequent experiments made it appear, however, that death was brought about rather by the toxic action of the CO_2 , which must penetrate, therefore, with extraordinary rapidity.

It was then found that in brine in which 1 part of O_2 and 65 parts of CO_2 were dissolved (by bubbling equal volumes of the gases through the liquid) the *Artemias* lived about 30 minutes. With 1

part of O_2 to 3 parts of CO_2 in solution, the *Artemias* were still active after several hours. It would appear at least, then, that the animals quickly absorb CO_2 from high tensions, and that inability to excrete CO_2 against the tension of the medium is very quickly lethal, whereas only minimal¹⁶ quantities of oxygen are required.

Ranson (1927) points out that gasses, like other solutes, cannot be absorbed in less than atomic quantities and are probably taken in molecular form, and therefore simply represent a special case of permeability to substances dissolved in water.

Summary.—It may be said that in general the *marine* invertebrates investigated are permeable to water, salts, and organic solutes, whether through the integument or gut: that teleosts and fresh water invertebrates have very slight permeability. Whether or not aquatic animals with chitinous integuments do absorb organic matter from solution,¹⁷ there is no theoretical evidence that such action is impossible.

THE USE OF DISSOLVED ORGANIC MATTER BY AQUATIC ANIMALS.

a. PREVIOUS EXPERIMENTS.

The possibility has not been entirely eliminated that dissolved organic matter may be present in useful quantities in the sea. Moreover, there is reason to believe that many aquatic animals are sufficiently permeable to allow the penetration of such substances.

As was stated in the first section of this paper, however, there is great reason to doubt the effectiveness of experiments hitherto made on animals to test whether or not they can actually make use of dissolved organic matter as food.

Accordingly, it seems wise to discuss—at least to some extent—the results and the shortcomings of the recorded experiments.

It is obvious from the work of Pryzlecki (1922) that under some conditions frogs can absorb certain utilizable organic compounds, but such results do not mean that a frog can live a fairly normal life,

¹⁶ It was found that if the air was exhausted from the medium containing them by means of a vacuum pump, they lived for several hours. It thus appears possible that the *Artemia* can build up a considerable oxygen deficit.

¹⁷ It may be noted here that the absorption of various salts by marine forms (as Cobalt by the Lobster) from extremely small quantities in the sea is not comparable to the substances considered here. The Cobalt, Strontium, or whatever (see Harvey, 1928, p. 51, for a list) is deposited by the animal in question in an insoluble form from which loss is negligible.

even for a time, in a solution—that is, grow or reproduce. And it is equally clear that various lamellibranchs can actually oxidize sugar absorbed by them. But there is no reason to suppose that an oyster could long remain healthy on a purely liquid diet. In fact the experimenters are unanimous in saying that lamellibranchs normally depend on particulate matter for their food. The work of Yonge, for example, shows that the oyster is unable to absorb glucose through the body wall, unless it is in a definitely pathological condition.

Observations in natural habitats.—There are a few observations and calculations under natural conditions that may be of some value. Merejkowski (1879) found hydromedusae of two species which had no manubrium and with no external opening of the gastrovascular system at all, and yet which had reached the same size as normal specimens with which they were associated, but there is no indication that the losses had occurred early in life. The organisms may have been attacked or parasitized just before observation and the rapacity of certain medusae¹⁸ and, among the ctenophores, of *Beroë* is well known.

It has been pointed out that such forms as larval eels with a hair-like intestine, forward pointing teeth, ill closing jaws and large surface area, might find the use of particulate food difficult and the use of dissolved food easy.

Pütter (1909b) cites some figures for the Rhine salmon which may be considered here, especially as Krogh omits all mention of them.

It is known that the salmon travel directly up the Rhine from the mouth to the spawning grounds without feeding. Since the skeleton alone is involved, there is no loss or gain in length during the journey. Pütter (to be certain he was dealing with the same or comparable fish) obtained the weights of a given length-group of salmon near the mouth of the Rhine, and again at the spawning beds. From the difference in weight he was able to calculate how much energy could have been produced by the oxidation of body tissues.

Pütter then determined the total difference in elevation of the two places; the speed of the descending water; the average speed of the fish; and the resistance of a salmon of the chosen size to passage through the water at the speed it would have to travel; and from these data he calculated the work that would have to be done to reach the spawning grounds. This total required work was more than Pütter could account for by the loss in weight of the fish. Whence he con-

¹⁸ Cf. Lebour (1922) and Delap (1906).

cluded that the fish must absorb dissolved food from the waters of the Rhine.

In these calculations, however, Pütter used the fresh weights of the salmon. But it is well known that the percentage of water in the tissues is very high in salmon at the spawning grounds compared to those leaving the sea—a fact of which Pütter seems unaware. Taking this into consideration, the *dry* weight difference might be expected to account for the energy expended without the necessity of parenteral feeding.

Cladocera.—Perhaps the first actual experiments were those of Knörrieh (1901) on *Daphnia*. Krízenecký (1925a) summarizes his work as follows: (p. 83):

¹⁹“Knörrieh used in his experiments on *Daphnia* a sterilized and filtered hay-infusion, which was changed daily. The *Daphnia* lived 14 days, and bore a usual number of young which grew in the solution. Knörrieh concludes from these experiments that dissolved organic substances are taken in and absorbed by the crustacea.

However, we must now take into consideration of Knörrieh's work this criticism. Wolff showed subsequently that if one centrifuges a normal, filtered hay-infusion (such as Knörrieh used), a mass of fine particles is obtained with which another cladoceran, *Simocephalus*, can successfully be fed.”

It may be added that in such a hay-infusion, bacteria introduced with the *Daphnia* might easily multiply rapidly enough to be an appreciable source of food. Naumann (1918, 1921) stresses the importance of fine detritus with the attached bacteria as food for cladocera under natural conditions.

Wolff (1909) used *Simocephalus* (now *Simodaphnia*) in filtered aquarium water. The adult females molted and gave birth to young, and the young increased in size and also molted, living for 21 days. His conclusion was that they were making use of dissolved substances in the water. The possibility of bacteria as food, though much less than in a hay-infusion was by no means avoided.

Wolff's method of determining growth was attacked by Kerb (1910) among others. He pointed out that in the crustacea, the increase in size did not necessarily mean increase in mass, and that dry weight should be the criterion. Using a somewhat more careful defense against the growth of bacteria, he found that *Daphnia* molted readily, but lost weight during the process, as determined after drying.

¹⁹ Translated.

But since, as pointed out, Wolff's control of bacteria was the less rigid, and since his animals seemed healthier and lived longer than Kerb's, they may actually have increased in weight, though not on dissolved food.

Kerb also kept *Corethra* larvae in a 0.05% solution of dextrose and found no diminution of the sugar on subsequent analyses. The same method with mixed plankton from net hauls showed a sugar use scarcely outside the experimental error. With elvers he got negative results. This is somewhat surprising, as the medium could not be changed, and bacteria (which his washing of the experimental animals could scarcely eliminate altogether), might have been expected to use some of the sugar.

Fish.—Pütter (1909a, 1911, 1922) performed a number of experiments on fish (*Hippocampus*, *Balistes*, *Scorpaena*, *Gobius*, *Heliastes*), and on *Ascidia mamillata* and on *Actinia aquina*, but Lipschütz (1910, 1913) and Krogh (1931), have cast so much doubt on his positive results that it seems unnecessary to treat of this work of Pütter's at all, except for one experiment.

This (1909a) was comparing the oxygen use, the weights, and the length of life²⁰ of goldfish in a glycerine-asparagin solution with those in plain water. The fish in the solution lived longer, used far more oxygen and lost less weight than those in the plain water. Lipschütz did not strongly criticize this work, but Dakin and Dakin (1925) following the same technique and using many more fish come to quite other conclusions. They show that:

"Pütter did not employ enough specimens to cut out individual variation and a chance result."

And, on p. 321:

" The addition of the organic compounds, glycerine and asparagine, makes no difference to the duration of life, and the consumption of oxygen by the fish living in tap water with these compounds does not exceed that of the control fish in tap water only"²¹

It may be added that such experiments on oxygen use which are of short duration may introduce errors because of change of the environment of the animal. Such changes (of light, osmotic pressure,

²⁰ Those in tap water lived 42 days; those in the solution up to 56 and 78 days.

²¹ They also attack Pütter's inferences from his various determinations of oxygen use, both on theoretical grounds and in the light of their own experiments on Plaiice eggs, goldfish, *Anodon* and *Axolotls*.

change in the composition of the medium, etc.) may disturb the experimental animal and so raise its metabolic rate for a longer or shorter period. In the case of experiments of longer duration, there is always some danger of the growth and metabolism of microorganisms affecting the results.

Amphibia.—Though many marine fish have pelagic larval stages, the experiments on mature fish, which have just been discussed, are perhaps not entirely germane to a discussion of the marine zooplankton, more especially (as has been seen) since teleosts have been found to be relatively impermeable.

Still less relevant are the experiments of Krízenecký and his associates (Cf. bibliography) on amphibia larvae. There is some evidence that frog larvae can subsist on organic solutions, though Bock (1924) and Bonnet (1927) believe that bacteria in the solutions are the most important food source. Bock found that urodele larvae did not grow in the solutions, and Bonnet gives some evidence that absorption in the frog larvae is limited to the gut except in very strong solutions.

Mosquito larvae.—The latest experimental work that has come to my attention is that of Hinman (1930) with mosquito larvae.²² He sterilized the eggs of *Aedes aegypti*, and found that they hatched and developed to maturity in Berkfeld-filtered water from tubs in which mosquitos were breeding in large numbers. He added no nutriment of any sort. In a large number of cases "Bacterial tests showed the culture was sterile." The nature of these tests is not fully explained, but Hinman appears very certain of their efficacy.

Curiously enough, if the water was sterilized by autoclaving, the larvae failed to develop, unless there was an infection by bacteria of one or more varieties. In these cases development was normal.

Hinman's explanation is (p. 260):

"Doubtless the majority of secretory and excretory products of bacterial action would pass through a Berkefeld filter, and thus possibly supply the mosquito larvae with certain necessary substances. This might account for the fact that the larvae may be reared in water sterilized by filtration and still die in the same type of water when autoclaved."

But this explanation is seriously impaired, it seems to me, by the work of MacGregor (1929), whose paper is in part quoted by Hinman.

²² Krogh (1931), speaking of *Anopheles* larvae, says: "Any absorption of dissolved substances through the cuticle is out of the question;"

MacGregor raised the larvae of *Aedes argenteus*, under sterile conditions, on 1% of bread in distilled water. His medium was autoclaved at 120° C. for from 15 to 20 minutes. The eggs were sterilized with green soap and alcohol. A strain was kept under sterile conditions for four generations with no apparent decline in vitality, though the sterile mosquitos "rarely seem to reach a magnificence in general bodily development comparable with that" of insects raised in the presence of bacteria. But there is no doubt but that mosquito larvae can be raised in media sterilized by autoclaving. Hinman's conjecture thus becomes invalid and some other explanation of his results must be sought. It appears far from impossible that his filtering technique allowed the presence of bacteria in many of his filtrates, and that these, undetected by him, furnished food for the larvae. The cases in which the larvae failed to grow in the filtered medium would then be accounted for by supposing that only in these cases had true sterility been obtained.

In support of this suggestion, I can offer the facts (a) that the "water bacteria" are very difficult to detect by ordinary bacteriological technique (b) that I found (in experiments to be described subsequently) that filtrates were completely sterile only in about 1 case in 10, and (c) that Hinman's sterilizing agent (calcium hyperchlorite) was extremely inefficient in sterilizing eggs of *Artemia*.

Hinman's work must certainly be confirmed before it can be accepted.

In Hinman's later (1932) review of the subject, he places rather more emphasis on the probable role of colloids in the nutrition of the mosquito larvae, but his position is not made clearer.

b. INVESTIGATIONS ON COPEPODS AND *Artemia*.

Non-sterile.—Three mature or well grown specimens of the forms used were placed, after being washed in sterile sea water, in 100 cc. of 1:30 yeast-autolysate: sea water in a 200 cc. Ehrlenmeyer flask. Bacterial growth at the 20° C. of the laboratory was slow, but the specimens were taken out and washed and put into fresh solution in a sterile flask every 12 hours. The washing was accomplished by pouring the contents of a flask through a small net made of 20 mesh bolting silk. Sterile sea water was then poured over the animals. The net was kept in 70% alcohol when not in use, and was rinsed in sterile sea water before using. The results of the experiments are

given in Table VII. The controls in sterilized sea water were washed at the same times and subjected to the same amount of handling.

TABLE VII.

COPEPODA.

Non-sterile, in 1:30 yeast autolysate.

SPECIES	Flask No.	Length of life in hours.			Maximum length of life in sterile sea water. Same handling and washing.	Maximum length of life in <i>Platymonas</i> culture.
		Specimen No. 1	Specimen No. 2	Specimen No. 3		
<i>Calanus finmarchicus</i>	1	24	36	60		
	2	12	36	36		
	3	24	48	48		
	Max.			60	60 hrs.	2 months +
<i>Euchaeta sp.</i>	1	12	24	36		
	2	12	48	48		
	3	24	36	36		
	Max.				36 hrs.	5 weeks +
<i>Tigriopus fulvus</i>	1	48	48	120		
	2	48	60	312		
	3	60	72	192		
	Max.				120 hrs.	several months many generations.

The disproportionately long life of *Tigriopus* may have been caused by its very small size and probable ability to make better use of the bacteria present as food. Or the early death of the other, more delicate forms may have been a result of the handling. In any case, the experiments are entirely inconclusive.

The same experiment made with *Artemia* using 10 individuals, gave a maximum length of life of 144 hours. The maximum length of life in sterile sea water for 10 individuals was 12 hours less, but fewer specimens died in the first 48 hours. The same criticism holds for this result as the last.

Artemia under sterile conditions.

Five *Artemia* raised on a sterile culture of *Colpidium campylum* to the 6th instar were placed in a 1:20 solution of yeast autolysate in sea water 1% dextrose. The increase in NaCl killed the *Colpidium* without affecting the *Artemia*.

All five specimens died within 4 days without molting.

Experiments on Sterile Artemia.—As has been observed, the most important reason for doubting or rejecting the results of the experiments which have just been described, is the failure adequately to control bacteria, and there is strong reason to suspect that these latter may—at least in many cases—serve as a source of food. It was deemed necessary, therefore, to work with some form that could be kept under completely sterile conditions throughout the course of experimentation.

Likewise a fair test of parenteral feeding must be made upon an animal with a large surface area compared to its volume. In addition, it should be made upon a form which is known to be at least to some extent permeable.

*Artemia*²³ appeared to fulfill these three prerequisites better than any other available animal. It has been shown that there is good reason to believe it permeable. In its relative surface area, though some of the very small cladocerans and copepods must surpass it in this respect, *Artemia* must compare well with *Calanus finmarchicus*, *Euchaeta norvegica* and other common pelagic copepods. And judging by the cast integuments, the chitinous membrane through which the food would have to pass is considerably thinner than in *Calanus*. But the most important reason for using *Artemia* in the following investigations was that its eggs are covered with a heavy chitinous

²³ *Artemia*, though not occurring naturally in the sea as far as I have been able to discover, none the less appears to be physiologically a marine animal. Growth is more rapid, mortality lower and size larger in sea water than in solutions of greater density. The fact that it is found restricted to salterns is, I believe, owing to its being without adequate means of protection or escape from enemies, especially fish, which have much less resistance to high salt concentrations, and hence cannot live in the brines where *Artemia* is found. Cf. Boone and Baas-Becking (1931).

integument which renders them relatively impermeable, with the result that they may readily be subjected to strong bacteriacides without being destroyed.²⁴ And it is thus possible to be certain that a solution containing *Artemias* is really free of other organisms and of particulate food in general.

Normal life history.—Before describing the experiments, the normal development of the form must be considered in order that the effect of the experiments may be made clear, and that criteria of growth may be established. Heath (1924) gives an excellent account of the successive stages.

In the normal course of development, the egg hatches into a true nauplius (Fig. 12, no. 1). This nauplius is usually reddish in color, and heavily loaded with yolk. The gut is not open at either end. Under any circumstances not actually lethal, the nauplius undergoes an ecdysis after from 1 to 6 days (at 20°) and becomes in the second instar, a metanauplius (no. 2). In filtered sea water, especially if no bacteria are present, no further growth occurs, and the animal dies in from 3 days to 3 weeks. Especially among those that have been starved a long time, there may be a slight increase in length and possibly the rudiments of an additional pair of swimming legs appears (no. 3). And it is just possible that Heath has failed to note one ecdysis and instar at this point. But the animals, in starvation, have never been observed to reach Heath's 3d instar (no. 4).

It seems certain, therefore, that the appearance of the 3d instar is an absolute criterion of growth, and definitely requires the utilization of some extra-vitelline food supply.

Under suitable conditions, the instars succeed each other rapidly. The metanauplius form is lost about the 8th or 9th instar. The completely mature form is assumed in the 11th instar. Clasp-

²⁴ A considerable effort was made to sterilize the eggs of a number of pelagic copepods, especially of *Euchaeta*, sp. which was carrying large masses of its bright blue eggs, but no success was ever obtained. In every case the eggs were either killed by the sterilizing agent, or else contaminated; sometimes both. Washing many times in sterile water, and various dilutions of a number of germicides were tried, but to no effect. It was found that the eggs of *Tigriopus fulvus* could be sterilized—at least there was one successful batch, but the nauplii died so soon after hatching that the experimental solutions could not be prepared. It would no doubt be possible to repeat some of the *Artemia* experiments on this form, but since *Tigriopus* is a thick-shelled, non-pelagic form, with eggs which are difficult to detach from the females, and with extremely minute young stages, it seems generally so unsuitable that further experiments with it have not been attempted.

first occurs in the 12th instar, and the production of eggs, or living nauplii in the 13th, and continues in the 14th if a 14th instar actually

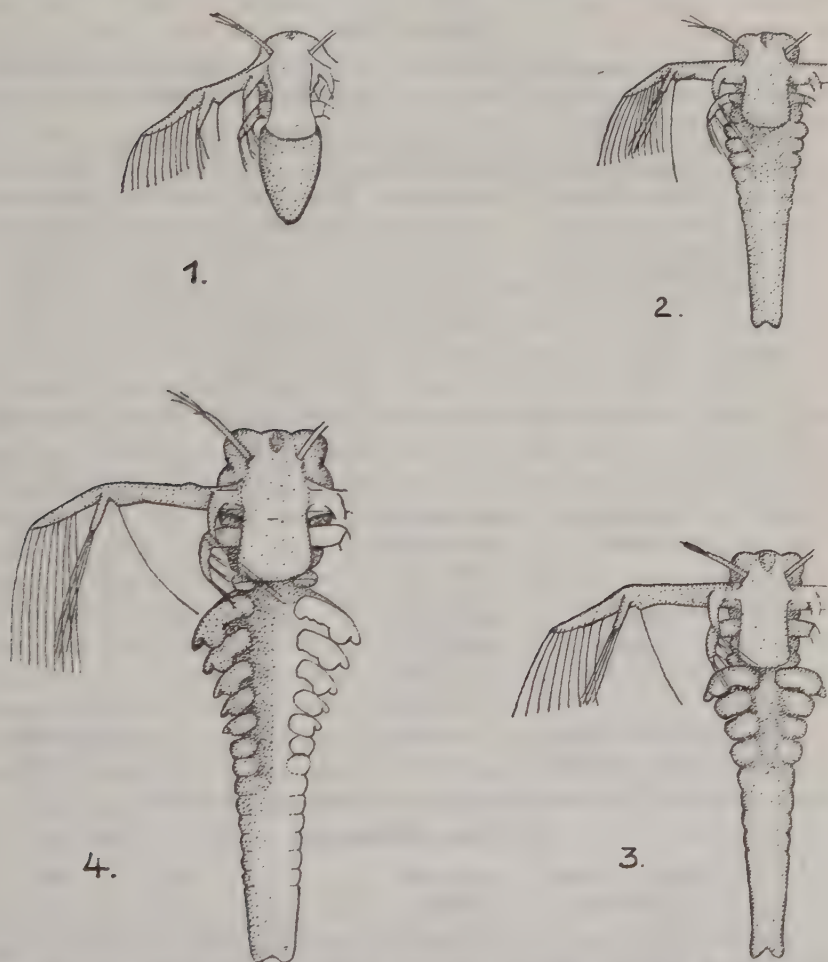


Fig. 12. Early stages of *Artemia*. 1, nauplius; 2, second instar; 3, third instar (?)—the most advanced stage reached without extra-vitelline food; 4, Heath's "third instar." All $\times 75.7$ (1, 2 and 4 partly after Heath (1924)).

occurs. Heath is not perfectly certain on this point. Clasping, under very favorable conditions, occurs on about the 18th to 20th day from hatching.

The cultures given in Table VIII will serve as examples and controls for the experiments about to be described.

TABLE VIII.

Growth rates in non-sterile cultures of various sorts used as controls. The variations are owing partly to differences in sterilization, and partly to variations in the number of algae present.

Artemia eggs sterilized and put in non-sterile cultures of other organisms.

No. of exp.	Predominant food organism.	Salt concentration.	Days till 3rd instar.	Days till 8th instar.	Days till mating.
C A ₂	<i>Platymonas subcordaeformis</i> *	Sea water (3.4%)	12	Not recorded	Not recorded
C A ₄	do.	do.	10	32	37
CP A ₃	do.	do.	9	23	29
CDu A ₅	<i>Dunaliella viridis</i> *	Sea water + 11.5% NaCl (total 15%)	9	25	31
C A ₁₂	<i>Dunaliella salina</i> *	Sea water + 26.5% NaCl (total 30%)	10	24	31
Nl A ₆	<i>Nitzschia closterium</i> f. <i>minutissima</i> *	Sea water	7		9th instar 27 days
C A ₄ C	<i>Platymonas subcordaeformis</i>	Non-sterilized eggs Sea water (3.4%)	7	22	28

* *Platymonas subcordaeformis* is a quadriflagellate motile green alga with optimum salinity about that of sea water.

Dunaliella viridis is green, biflagellate with optimum salinity of about 5-10%.

Dunaliella salina is green or orange in color, optimum salinity about 15-25%.

Nitzschia closterium f. *minutissima* came originally from the laboratory at Plymouth, England.

Preparation of the eggs.—The eggs were collected at the salterns at Elkhorn Slough and were sterilized by shaking in a 1:1000 HgCl₂

solution for 15 minutes and then placed, using ordinary aseptic technique, in a 1:30 yeast autolysate-sea water solution and allowed to hatch. In 3 or 4 days most of the individuals already hatched had reached the second instar. (This occurs equally rapidly in distilled water with 3% NaCl.). Any bacterial contamination would be likely to cloud the medium in this period. This method was used for the purpose of detecting faulty sterilization, as the preparation of the experimental solutions was tedious, and it was thus often possible to prevent their infection by non-sterile eggs. If the medium remained clear, some of it, containing a variable number of nauplii (usually about 50-100) was poured into the experimental flasks. These were tested for bacteria²⁵ in all cases where (a) turbidity appeared, (b) growth of the *Artemias* occurred, (c) death of all the nauplii occurred in 5 days or less from hatching, (d) a precipitate formed. And also in *all* the experiments of the first two series. All flasks found contaminated were, of course, discarded, and a new set-up was made if needed to complete the series. In the lower concentrations the preliminary test had to be dispensed with, as the addition of the 1:30 yeast autolysate would have affected unduly the concentration of the experimental media. In these cases the eggs were hatched in sterile sea water. Two controls were usually run with each batch of eggs sterilized, one (C.) consisted of sterilized eggs put into a stock culture of *Platymonas subcordaeformis* in nutrient sea water. The other (C/C) consisted of unsterilized eggs from the same batch put in *Platymonas* culture.

In the first series 100 cc. of medium was used. In all subsequent experiments 150 cc. was used in 250 cc. Pyrex Ehrlenmeyer flasks, unless otherwise specified.

The results of these experiments are shown in the accompanying tables.

Yeast autolysate media. Yeast autolysate has proved an admirable Nitrogen source for bacteria, yeasts, molds, algae, and for the ciliate, *Colpidium campylum*. It is in nearly every case superior to peptone, and equal or superior to peptone bouillon or other mixtures. It passes readily through a fine bacterial filter. It contains roughly 1% nitrogen, or the breakdown products of some 6% of original protein.²⁶

As will be observed, no growth was obtained in any of the experiments shown in Table IX.

²⁵ Cf. Section on nutrition of Ciliates.

²⁶ For method of preparation see Hetherington (1932).

TABLE IX.

Sterile *Artemia salina* in solutions sterilized by autoclaving for 10 minutes at 120° C. and 20 pounds pressure. No carbohydrate.

No. of Exp.	Solute N. Source	Concentration	Solute Carbohydrate	Concentration	Amt. NaCl added	Solvent	Instar reached	Length of life in days
A ₂ 0	—	—	—	—	—	Sea wa.	2nd	7
A ₄ 0	—	—	—	—	—	Sea wa.	2nd	5
A ₇ 0	—	—	—	—	—	Sea wa.	2nd	6
A ₂ 1	Yeast autolysate	1:100	—	—	—	Sea wa.	2nd	6
A ₂ 2	do.	1:75	—	—	—	do.	do.	7
A ₂ 3	do.	1:50	—	—	—	do.	do.	6
A ₂ 4	do.	1:30	—	—	—	do.	do.	7
A ₄ 4	do.	1:30	—	—	—	do.	do.	10
A ₂ 5	do.	1:20	—	—	—	do.	do.	6
A ₂ 6	do.	1:10	—	—	—	do.	do.	9
A ₄ 6	do.	1:10	—	—	—	do.	do.	11
A ₄ 7	do.	2:10	—	—	—	do.	do.	10
A ₅ 7	do.	2:10	—	—	—	do.	do.	13
A ₄ 8	do.	3:10	—	—	—	do.	do.	8
A ₅ 8	do.	3:10	—	—	—	do.	do.	15
A ₄ 9	do.	4:10	—	—	—	do.	1st	3
A ₄ 10	do.	5:10	—	—	—	do.	1st	3
A ₅ x	<i>Artemia</i> egg extract	1:500	—	—	—	do.	2nd	10
A ₅ Y	do.	1:100	—	—	—	do.	2nd	12
A ₅ z	do.	1:10	—	—	—	do.	2nd	31+

These experiments were conducted with only one experimental animal, and as the complete results for the several series are given in Table X.

TABLE X.

Results of Experiments in the Psychology of the Development of the Rat.

No. of Expt.	Age of animal	Time of day	Time of day	Time of day	Time of day	Time of day	Time of day	Time of day
1st	1st	1st	1st	1st	1st	1st	1st	1st
2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd	2nd
3rd	3rd	3rd	3rd	3rd	3rd	3rd	3rd	3rd
4th	4th	4th	4th	4th	4th	4th	4th	4th
5th	5th	5th	5th	5th	5th	5th	5th	5th
6th	6th	6th	6th	6th	6th	6th	6th	6th
7th	7th	7th	7th	7th	7th	7th	7th	7th
8th	8th	8th	8th	8th	8th	8th	8th	8th
9th	9th	9th	9th	9th	9th	9th	9th	9th
10th	10th	10th	10th	10th	10th	10th	10th	10th
11th	11th	11th	11th	11th	11th	11th	11th	11th
12th	12th	12th	12th	12th	12th	12th	12th	12th
13th	13th	13th	13th	13th	13th	13th	13th	13th
14th	14th	14th	14th	14th	14th	14th	14th	14th
15th	15th	15th	15th	15th	15th	15th	15th	15th
16th	16th	16th	16th	16th	16th	16th	16th	16th
17th	17th	17th	17th	17th	17th	17th	17th	17th
18th	18th	18th	18th	18th	18th	18th	18th	18th
19th	19th	19th	19th	19th	19th	19th	19th	19th
20th	20th	20th	20th	20th	20th	20th	20th	20th

During the course of the experiments the animals were of different ages, and it is a point of considerable significance for the results. First, the behavior of rats is greatly affected with age, and since the behavior is so much affected the same, and since the "length of the" is taken as a basis for behavior in the case of the rat, the behavior of rats of different ages will give an important difference. Secondly, there is evidence that the percentage of rats behaving in a particular way is a function of the length of exposure to the light, length of exposure to the light, and possibly also the length of exposure to the light. There is also the fact that the behavior of rats will be greatly affected by the length of exposure to the light.

Thus, on the basis of the experiments it appears that the behavior of rats is a function of the length of exposure to the light.

It is the conclusion of the experiments of these rats that the same behavior will be given by the same animals.

lysate: sea water, and 1:20 yeast autolysate: sea water 1% + dextrose are especially favorable.

Media sterilized by filtration.—At this time Hinman's (1930) paper was called to my attention, and since he seemed to obtain growth of mosquito larvae in filtered media only and never in media sterilized by heat, and also, since he had found water in which mosquitos bred to contain sufficient nourishment for normal development of the larvae, the experiments shown in Table XI were tried, the medium being sterilized in each case by means of a Seitz filter, No. 6.

TABLE XI.

Sterilized *Artemia* eggs in natural "nutrient" solutions sterilized by filtering through a Seitz filter.

No. of exp.	Liquid from:	Solvent*	% NaCl added	Instar reached	Max. length of life in days
A ₈ ¹	Sea water		—	2nd	5
A ₉ ⁵	<i>Platymonas</i> culture	Sea wa.	—	2nd	5
A ₉ ⁷	<i>Nitschia</i> culture	Sea wa.	—	2nd	5
A ₉ ⁸	<i>Artemia</i> + <i>Platymonas</i> cult.	Sea wa.	—	2nd	6
A ₁₀ ⁹	Sea water		11.5%	1st	1
A ₁₀ ¹⁰	<i>Platymonas</i> culture	Sea wa.	11.5%	1st	1
A ₁₀ ¹¹	<i>Dunaliella viridis</i> culture	Sea wa.	11.5%	1st	3
A ₁₀ ¹²	<i>Dunaliella salina</i> culture	Sea wa.	11.5%	1st	1
A ₁₀ ¹³	<i>Dunaliella salina</i> culture	Sea wa.	26.5%	1st	1
A ₁₀ ¹⁴	<i>Artemia</i> + <i>D. salina</i> culture	Sea wa.	26.5%	1st	1

* In all cases except A₁₀⁹ the salt was added when the culture was originally made up and the organism in question had been growing healthily for 2-6 weeks before the filtering was done.

It was first determined that the metal parts of the filter, though containing copper, do not in any way make toxic the liquids which come in contact with them, either for *Artemia* or for any of the flagel-

TABLE XII.

Sterilized *Artemia* eggs in solutions containing an added source of organic nitrogen. Sterilized by filtration. No added carbohydrate.

No. of Exp.	Source of organic Nitrogen	Concentration	Solvent	% added NaCl	Instar reached	Maximum length of life in days	
A ₈ ²	Yeast autolysate	1:100	Sea wa.	—	1st	3	
A ₈ ³	do.	1:50	do.	—	2nd	6	
A ₈ ⁴	do.	1:10	do.	—	2nd	15	After the 8th day only a single individual which probably hatched late
A ₁₃ ²⁴	<i>Dunaliella salina</i> autolysate	1:500	do.	—	2nd	7	
A ₁₃ ²⁵	do.	1:75	do.	—	2nd	9	
A ₁₃ ²⁶	do.	1:20	do.	—	2nd	10	
A ₁₃ ²⁷	do.	1:500	do.	26.5%	1st	1	
A ₁₃ ²⁸	do.	1:75	do.	26.5%	1st	2	
A ₁₂	Artemia digest	1:10	do.	—	2nd	14	
A ₁₂ ¹⁸	do.	1:100	do.	—	2nd	19	
A ₁₂ ¹⁹	do.	1:50	do.	—	2nd	38	
A ₁₂ ²¹	do.	1:100	do.	26.5%	1st	3	
A ₁₂ ²²	do.	1:50	do.	26.5%	1st	2	
A ₁₂ ²³	do.	1:10	do.	26.5%	1st	6	
A ₂₀ ⁴	Peptone	0.2%	do.	—	2nd	13	
A ₂₀ ⁵	do.	0.5%	do.	—	2nd	9	
A ₂₀ ⁶	do.	1. %	do.	—	2nd	12	

Since these results indicated that the method of sterilization of the solutions had little or no effect on the length of life, autoclaving was used in some of the subsequent work.

lates used in later experiments. The Seitz filter is quicker, and more convenient in many ways than the porcelain candle.

Although the Seitz filter is run by pressure instead of suction, and so is superior to the candle form in respect to a frequent source of contamination, none the less only about 1 filtrate in 10 proved to be sterile. This was no doubt in part due to non-sterile eggs and partly to faulty technique, but the contamination of the autoclaved media was much less frequent.

From Table XI it can be seen that none of the cultures which was capable of supporting *Artemia* unfiltered was able to do so after filtration. The experiments made with strong brines seem to show that these are definitely less suitable for *Artemia* than is sea water, and appear to support the suggestion already made: that *Artemia* inhabits brines because it can and its enemies cannot, rather than because brines are physiologically favorable to it.

An examination of Table XII will show that there was the same complete lack of success with solutions of various Nitrogen sources sterilized by filtration as in the "natural" solutions, and in the nitrogenous solutions sterilized by autoclaving. At about this time

TABLE XIII.

Sterilized *Artemia* eggs in solution of non-nitrogenous carbon sources.
Sterilized by autoclaving.

Exp. No.	Carbon Source	Concentration of carbon source	Solvent	Instar reached	Maximum length of life in days	
A ₂₆ ¹¹	Glycerine	0.1%	Sea water	2nd	17	
A ₂₆ ¹²	do.	0.5%	do.	2nd	18	
A ₂₆ ¹³	do.	1.0%	do.	2nd	16	
A ₁₉ ^L	Dextrose	0.5%	do.	2nd	25	600 cc. in liter flask
A ₁₉ ²	do.	1.0%	do.	2nd	18	
A ₁₉ ²	do.	2.0%	do.	2nd	17	
A ₂₆ ¹⁴	Maltose	1.0%	do.	2nd	19	

TABLE XIV.

Further experiments with sterilized *Artemia* eggs in solutions containing sources of both nitrogenous and non-nitrogenous organic matter.

Exp. No.	Nitro- gen source	Concen- tration	Carbon source	Concen- tration	Solvent	Instar reached	Length of life in days	Method of ster- ilizing solution
A ₁₆ ¹	Artemia digest	1:20	Dextrose	1. %	Sea water	2nd	9	filtering
A ₂₁ ⁷	Peptone	.2%	do.	.2%		2nd	15	auto- claving
A ₂₁ ^{8K}	do.	.2%	Sucrose	.2%		2nd	14	do.
A ₂₁ ⁹	do.	.2%	Dextrose	1. %		2nd	18	do.

McGregor's paper was obtained which seemed to invalidate Hinman, so that sterilization by filtration was largely discontinued, and auto-claving was again used.

Tables XIII and XIV show further completely unsuccessful experiments with other sources of food.

Media with vitamines. In order to see if the commoner vitamines had anything to do with the failure of *Artemia* to grow in solution, the experiment shown in Table No. XI was tried, using Squibb's cod liver oil, and a Squibb product called "Vitavose" containing vitamines B₁ and B₂.²⁸ The results are shown in Table XV.

²⁸ The formula printed on the label is:

APPROXIMATE COMPOSITION.

Maltose.....	38%
Malto-Dextrins.....	20%
Dextrins.....	20%
Soluble Proteins.....	8%
Soluble Amino and other Nitrogenous Substances.....	7%
Mineral Salts.....	4%
Moisture.....	3%

VITAMIN B CONTENT.

"Vitavose contains at least 100 times as much of the antineuritic factor as does fresh, raw, certified, whole cow's milk (tested biologically by modification of the methods described by Osborne and Mendel, J. Biol. Chem. 54, 743, 1922): and at least 33 times as much of the pellagra preventing factor."

TABLE XV.

Sterile *Artemia* eggs in solutions containing vitamins.

Solutions sterilized by filtering.

Exp. No.	Nitro- gen source	Con- centra- tion	Vitamin source	Con- centra- tion	Sol- vent	Instar reached	Maxi- mum length of life in days	
A ₁₂ ¹⁹	Artemia digest	1:50	None	—	Sea water	2nd	38	Also given in table XII
A ₁₂ ^{19c. l. o.}	do.	1:50	Cod liver oil	1%	do.	2nd	31	
A ₁₂ ^{19c. l. o. v.}	do.	1:50	Cod liver oil vitavose	1% .5%	do.	2nd	28	
A ₁₂ ^{19v.}	do.	1:50	vitavose	.5%	do.	2nd	30	

The solutions containing the cod liver oil were well shaken in a flask and then filtered through the Seitz filter. Only 100 cc. were used so that the sterilization could be made with one filling of the filter. The filtering process created an extremely fine emulsion which was not broken up for some days.

It is probable in these experiments that the unusual apparent length of life was due to delayed hatching, for first instar nauplii were noted till very near the end. The only sure result is the vitamin-containing cod liver oil and "Vitavose" did not cause growth under the conditions of the experiment.

Media containing inert particulate matter. Since some of the experimental solutions were of considerable strength and seemingly nutritious, the possibility suggested itself that not only were the Artemias unable to absorb nourishment through the integument, but that they were keeping their guts closed, and hence failing to absorb any nourishment by the intestine. Therefore solutions were made up in the normal way, and to them was added a small amount (roughly 0.25–0.5 gm.) of sterilized bone black in sea water. The purpose was to see if the Artemias, encountering these particles would not take them in, and in the process ingest enough of the solution to cause them to grow. In a few experiments powdered carmine was used instead, but

since it appeared to be taken in less rapidly its use was discontinued. The results are summarized in Table XVI.

TABLE XVI.

Sterile *Artemia* eggs in solutions containing non-nutrient particulate matter.

Exp. No.	Nitrogen source	Concentration	Solvent	% added NaCl	"food carrier"	Instar reached	Maximum length of life	Method of sterilizing solution
A ₇ ⁴ carb.	yeast autoly-sate	1:30	Sea wa.	None	Carbon	2nd	32	Autoclaving
A ₇ ⁴ carm.	do.	1:30	do.	None	Carmine	2nd	9	Autoclaving
A ₇ ⁶ carb.	do.	1:10	do.	None	Carbon	2nd	32+	Autoclaving
A ₇ ⁶ carm.	do.	1:10	do.	None	Carmine	2nd	32+	Autoclaving
A ₁₅ ³⁶	Dunali-ella autoly-sate	1:50	do.	11½%	Carbon	1st	3	Filtering
A ₁₅ ³⁷	do.	1:20	do.	None	Carbon	2nd	53	Filtering
A ₁₅ ³⁸	do.	1:20	do.	11½%	Carbon	2nd	11	Filtering

The carbon-containing solutions showed more contamination than any others and it is suspected that like precipitated CaCO₃, bone black cannot be successfully sterilized by autoclaving.

The eggs in sea water solutions with carbon seemed particularly prone to delayed hatching, as evidenced by the invariable presence of 1st instar nauplii until the very end. In a brine of more than 6% NaCl the great majority of eggs fail to hatch, so that this effect is largely absent, only the nauplii already hatched in preliminary solutions ever being present in most cases.

The 2nd instar *Artemias* ingested both the carmine and the carbon, especially the latter. But these did not appear to enable the animals to grow. Careful search under the microscope failed to reveal the presence of any *Artemia* more advanced than the 2nd instar.

These results might be interpreted to mean that none of the solutions tried was suitable as food for *Artemia*, even though ingested. However, a consideration of the feeding method of the animal, and of some later experiments with killed food organisms appeared to show that this was possibly not correct.

Artemia, unlike many of the fresh water anostracans, seldom stirs up the bottom, but swims free above, and it is probable that very little carbon or carmine was ingested. The solutions were perfectly clear except when, one or twice a day, they were shaken slightly.²⁹

As has been remarked, it is a logical necessity that any animal which depends on dissolved foodstuffs in natural waters shall have the ability to utilize a wide variety of substances, and even if the yeast autolysate dextrose should prove unsuitable, even in particulate form, this can only be considered as strong evidence that *Artemia* cannot use dissolved foods at all. For it is incredible that a more easily assimilable combination of basic foodstuffs than the amino-acids and simple hexose of the experimental medium could ever be found under natural conditions in natural waters.

Sugar analysis of media. Although the slightly longer life of *Artemia* in some of the solutions containing sugar was almost certainly merely the result of delayed hatching, there existed a remote possibility that some of the carbohydrate is actually taken in, by whatever process, from the simple solutions.

It was, therefore, hoped to place a large number of sterile *Artemia* nauplii or eggs in solutions of various sugars, and attempt to discover by means of analysis if any of the sugar were utilized. The experiment was tried no less than 18 times, but without definite results in any case.

In the experiments already described it was only necessary to have comparatively few sterile nauplii in the various solutions, but in

²⁹ A Schott aeration flask was set up with a solution of 1:20 yeast autolysate + 1% dextrose in sea water. In suspension there was a little blood charcoal and some diatomaceous earth which had been cleaned with a mixture of concentrated sulphuric and nitric acid followed by washing with distilled water. A number of the *Artemia* grew to the 5th instar in 15 days, when the experiment had to be discontinued. The medium appeared to be entirely sterile, though the plates and solutions could only be kept four days. It has unfortunately been impossible in the subsequent months to effect another sterile set-up so as to check the original observation, so that this observation is merely given for what it is worth, and cannot be considered as definitely proved as yet.

experiments depending on analysis, it would be obviously needful to have a very large number in the solutions, or negative results might simply mean that too little sugar was utilized to be detected by the method used.

No combination of time of exposure and strength of HgCl_2 could be found that was satisfactory.³⁰ Invariably there were a few sterile nauplii, or a larger number of non-sterile ones.

In one experiment with a bacterial contaminant, the use of the sugar by the bacteria was well shown.

In six sterile experiments (with a maximum of about 1 nauplius to 10 cc. of medium) an interesting result was obtained. In all cases a large number of sterile eggs had been added to the solutions (1% dextrose in sea water). Of these only a few hatched into living nauplii, but many more split open and allowed the embryo, still encased in the thin inner membrane, to escape. The procedure was to leave the eggs in the solutions for about 6 hours before making the initial determinations, so as to eliminate any effect adsorption by the eggs might have. The second determination was made 10 days later. In every case the second determination gave *more* sugar³¹ than the first, though not much more. The method used, Schoorl (1930), is accurate to less than 1 mg. so that the differences are greater than the error.

The eggs may have liberated sugar or some other strong reducing substance. Of these the first explanation is perhaps the more probable. But the question of whether or not hatched *Artemia* can use some dextrose from solution remained unsolved.

In a final attempt to discover the facts of the case, about 500 cc. of *Artemia* eggs were hatched in several liters of salt water, through which a strong current of air was bubbled. The resulting nauplii (wet weight approximately 40 gm.) were placed in a flask with 500 cc. of the following solution:

NaCl	30 gm.
Dextrose	5 gm.
Water	1000 cc.

³⁰ Further endeavors with calcium hypochlorite, Sodium hypochlorite and Dakin's solution (up to 50 mg. free Cl per liter) never gave sterile eggs, nor did hexylresorcinol (proprietary preparation), nor alcohol. Mercurichrome and another proprietary organic mercury compound acted like HgCl_2 but rather less successfully.

³¹ Average at start of experiment .695%, at end, .712%.

and a current of air was kept running through the liquid. The solution was filtered off on coarse filter paper after 30 minutes (to wash the nauplii and acclimate them to the experimental mixture). They were then washed from the paper with 500 cc. more of the solution, and allowed to remain in it (still well aerated) for 15 minutes. They were again filtered off, the filtrate being passed into a flask (containing a few crystals of HgCl_2 to prevent any bacterial action) and reserved for analysis. The procedure was repeated and a second filtrate obtained. The nauplii were again placed in 500 cc. of the solution, and a current of CO_2 passed through the liquid in place of the air. Thirty minutes were allowed to make certain that all the nauplii were dead. The dead nauplii were then placed in a fresh 500 cc. of the solution, and air bubbled through for 15 minutes as before. The CO_2 would be less likely to destroy the microorganisms present than any other agent which would kill the *Artemia*, and a comparison of the final sugar content of this solution with that of the solutions that had contained the living nauplii should show what part of the dextrose used was taken in by the nauplii and what by the bacteria. Finally a portion of the unused solution was also preserved with HgCl_2 as an ultimate control.

The results of the analyses (Schoorl's method was again used) showed no detectable differences between the various solutions. In other words, neither the 40 gm. of living nauplii, nor the unknown (but small) quantity of bacteria removed any of the 2.5 gm. of dextrose present in the 500 cc. of medium. The time of exposure was, of course, short, and under the conditions of the experiment, the nauplii would have to take up about $\frac{1}{1000}$ of their own mass in the 15 minutes allowed in order to give appreciable results, or roughly $\frac{1}{10}$ their mass in 24 hours. This may appear higher than could be expected, at first glance, but crude reckoning from the lengths given by Heath, and allowing 3 days from the 2nd to Heath's 3d instar (the nauplii used in the experiment were in the 2nd instar), shows that the growth rate requires taking on about half the initial body weight in 24 hours. Moreover, since the nauplii are in constant motion, the energy requirements would not be negligible, so that it can be fairly concluded that 2nd instar nauplii of *Artemia* do not make an appreciable use of dissolved dextrose in the medium, even though it is present in much greater quantities than is possible under natural conditions.

Summary.—1. An extra-vitelline food source is necessary for *Artemia* nauplii to reach the 3d instar.

2. None of the numerous solutions tried allowed the nauplii to reach the 3d instar. That is, none of the solutions ever produced growth.

3. Analysis of the medium showed that dextrose was not taken up by the nauplii.

4. It is therefore concluded that *Artemia* does not and cannot depend on dissolved substances for its food supply.

THE UTILIZATION OF PARTICULATE FOOD BY AQUATIC ANIMALS.

Previous experiments.—As has been seen, no organic solution was discovered that *Artemia* could utilize. A review of the literature has shown no proved parenteral feeding by any form. It seems necessary, therefore, to consider particulate feeding by the zooplankton in general and especially by *Artemia*.

Little work under this head has been done. Indeed it is extremely difficult to prepare a particulate food which may not be expected to add some dissolved material which might be suspected of having some nutrient value. For this reason, such well known practices as feeding echinoderm larvae on diatom cultures (Cf. Allen and Nelson, 1910) cannot well be brought forward. Despite the arguments to the contrary, the work of Gran and his associates suggests that diatoms may be responsible for much of the dissolved organic matter in the sea, and most of the work with diatoms has been of too cursory a nature to distinguish between the effects of the particulate and dissolved substances in such a culture.

Important works on particulate feeding that have come to my attention are those of Naumann and that of Woltereck, though in neither case were there complete controls. Naumann (1918, 1921), considering various fresh water Cladocera, finds that they are active filterers; that they display no choice and that whatever of proper size is in the water is passed into the gut unchewed. By comparing the contents of the gut with food that has not yet reached the mouth, or with material obtained by centrifuging the medium, it is possible to tell what is actually made use of. Of the nannoplankton, only the *Chlamydomonas*-like forms were digested. The principal food was the "staubfeine" detritus with attached bacteria. The detritus is either autochthonous, from plankton and necton, or allochthonous, from shore wash, windborne material, etc. The forms studied,

especially *Daphnia* can very rapidly filter out particles approaching the limits of visibility.

Woltereck (1928) found that pelagic *Daphnia* cannot make use of detritus (though *D. magna*, *D. pulex*, and pond races of *D. longispina* can use it). But that pelagic *Daphnia* (and pelagic *Bosmina*) can use *Chlorella vulgaris* from pure cultures—either scraped from agar or grown in liquid—and also can use certain small flagellates. These pelagic Cladocera can also be fed on nannoplankton obtained by centrifuging, though the results vary depending on the forms present. *Scenedesmus*, *Raphidium*, *Kirchneriella* will not serve, nor will any of the blue-green algae tried, nor will net phytoplankton.

The best controlled work is that of Stuart, McPherson and Cooper (1931) on *Moina macrocopa*. They were able to free these cladocera from bacteria by repeated washings in sterile water, and then try individual foods. They found that living bacteria were necessary to *Moina* for long-continued (several generations were attained), natural growth. They also found great differences in the suitability of the various food-bacteria used. *B. coli mutabile*, and *A. aerogenes* were the most satisfactory nutritive material of the strains tried.

MacGinitie (1932) found that the geophycean, *Urechis caupo*, died after about two months if kept in rotted sea water (i. e., water kept in the dark until all organic matter is used by the bacteria present), death being obviously caused by starvation. Other specimens kept under like conditions, but fed on the same strain of marine *Pseudomonas* used by me in some of the experiments about to be described "showed a growth greater than that usually occurring in nature." *Urechis* is, of course, not a planktonic animal, but the experiment shows the importance of bacteria as food for invertebrates.

Experiments on Artemia; Algae.—*Artemia* grows very well on at least three flagellates as may be seen from the controls given above.³² *Artemia* grows equally well in a pure, bacteria-free culture of *Dunaliella salina* (obtained from Professor van Niel). The medium was: tap water 100 cc., yeast autolysate 1 cc., NaCl 5 gm., KNO₃ 0.04 gm., K₂HPO₄ 0.02 gm.

It might be argued by a very strict follower of Pütter that it was

³² I have not hitherto encountered any reference to the finding of *Platymonas subcordaeformis*, *Dunaliella viridis* or *D. salina* in samples of marine nannoplankton reported in the literature. I have, however, recovered the two former species from the open waters of Monterey Bay, and hence conclude that they may be considered as true marine species.

the substances given off into the medium that caused the growth and not the digestion of the organisms themselves. But this is largely a sophism when it is remembered that *Artemia* failed to grow in the medium after the algae had been removed by the Seitz filter, even though in this case it might be argued that a very few of the algae were necessary to supply certain accessory factors to the diet.

An attempt was made to discover some permeable membrane so that sterile *Artemias* could be placed on one side of it and *D. salina* on the other, but the experiment did not meet with success. Animal and celloidin membranes would not stand sterilization, and the finest Schott filter obtainable (No. 4) allowed the passage of the flagellates, as well as any "substances given off by them." No method could be devised by means of which only a very few *Dunaliella* could be given as food along with dissolved substances, without the *Dunaliella* immediately beginning to multiply rapidly.

It should be noted here that though growth to maturity occurred in pure cultures of *Dunaliella*, the death rate was generally lower by a considerable amount when bacteria were present also.

Ciliates. As it was desired to investigate as many types of nanoplankts as possible, and since holotrich ciliates are quite conspicuous in Monterey Bay waters, an attempt was made to isolate pure cultures of three species, but without success. It was, however, found possible to acclimate the bacteria-free culture of *Colpidium campylum* already discussed, by graduate concentration, to fifty percent sea water, or to 2% NaCl, both with yeast autolysate as food. A very good culture was obtained in 1.5% NaCl with yeast autolysate 1:100, and sterile *Artemia* nauplii placed therein grew to the seventh instar.³³

It is barely possible that in this case the yeast autolysate and the substances given off by these heterotrophic ciliates into the medium were the true source of nourishment, but this seems more preposterous than sound reasoning and is certainly not the simpler of the possible explanations for the observed facts.

Bacteria.—Since bacteria are usually the most abundant individuals in any sample of nanoplankton, it seemed especially worth while to try these as food for *Artemia*. The initial experiment was made

³³ In non-sterile cultures in 1.5% NaCl with *Platymonas*, it was impossible to raise these same *Artemia* beyond the 6th instar, so that the failure to reach maturity in the *Colpidium* cultures may well be due to too little salt rather than unsuitable food.

with a marine species of *Pseudomonas* isolated by Professor van Niel. This was grown on yeast agar plates, and was then scraped off with a piece of sterile fiber or cover glass, and added to sterile sea water, shaken until the agglomerations were completely broken up, and then inoculated with sterile nauplii. These lived for some days and reached the 6th instar. This method is an extremely useful one, as it is known that bacteria so scraped from the surface of agar contain minimal amounts of the nutrient material." The suspensions were left for five days before the artemias were added, so that there is little chance that any usable food escaped. It is possible, but seems to me extremely unlikely, that an animal such as *Artemia* can utilize excretory products of bacteria. So far I have been unable to devise a more explicit and critical proof of the ability of such a form as *Artemia* to live on discrete food alone. Various other species of bacteria isolated by me, or obtained from Professor van Niel were also used, with much the same results. Some of these species, being anaerobic, could not be grown on plates, and had to be added from the culture solution. The supernatant fluid was poured off in each case so as to add as little of the yeast autolysate (in which the bacteria were grown) as possible to the water. The results are given in Table XVII.

In addition to these experiments, note may be taken of the contaminated solutions in the previous work. The *Artemias* grew well in nearly every case in which bacteria appeared,³⁵ but in many cases they died after reaching the third or fourth instar. Nearly always such flasks were found to have an extremely rich growth of bacteria, generally of one of the spore-formers. These usually form a scum on the surface of the medium. It seems probable, in these cases, that the artemias died from lack of oxygen or too much CO₂. When the contaminant was of the *Pseudomonas* type, the *Artemias* usually lived till the 6th or 7th instar. In one case where the micro-organism was an extremely minute *Spirillum* a single female *Artemia* reached maturity in 43 days. The early instars were passed through with normal speed, and then a considerable slowing down occurred from the seventh on. It seems very likely that in the *Pseudomonas* and *Spirillum* contaminations the slowing down or death at the 6th or

³⁴ Henrici (1928) says, for example (p. 48): "The difficulties met with in broth cultures can be obviated by using solid media, agar slants, the cells being . . . obtained practically free of products of the medium itself by simply scraping them off with a wire loop. . . ."

³⁵ Hinman (1930) found the same thing with his mosquito larvae.

TABLE XVII.

Artemia in pure cultures of one (or two) organism(s).

Exp. No.	Food Organisms	% dissolved organic matter (protein equiv.)	Maximum length of life	Instar reached	Days to 3d instar	Days to 8th instar	Days to mating
A ₆ ^{ps1}	<i>Pseudomonas</i> sp.	none	37	6th	9	—	—
A ₆ ^{ps2}	do.	none	27	4th	9	—	—
Apy.	Yellow <i>Pseudomonas</i> (isolated by me)	none	21	6th	8	—	—
A ₁₆ ^{spf}	marine spore-former isolated by me	none	7	2nd	—	—	—
A _B ⁵	<i>Spirillum rubrum</i> * (Lister strain)	.06	13	5th	8	—	—
A _B ³	" <i>Streptococcus</i> " <i>varians</i>	.06	16	5th	9	—	—
A _B ⁷	do.	.06	4	2nd	—	—	—
A _B ⁶	do.	none	7	2nd	—	—	—
A _B ⁴	<i>Rhodobacillus palustris</i> <i>Sarcina lutea</i>	.06	5	2nd	—	—	—
A ₁₈ ¹	<i>Dunaliella salina</i>	.06	indef.	mature	5	14	24
A ₁₈ ²	do.	.06	indef.	do.	7	18	31
A ₁₂ ^{isc}	<i>Colpidium campylum</i>	.06	26	7th	8	—	—

*Possibly contaminated. (*Sp. rubrum*, *Str. varians* and *Rh. palustris* are of the photosynthetic Purple Bacteria.)

7th instars was caused by toxic excretory products of the bacteria, rather than by the use of too much of the available oxygen. That

the effect was caused by the inadequacy of the food is of course possible, but I think unlikely. No attempt was made in these cases to transfer the *Artemias* to fresh bacterial cultures in the same media. See Table XVIII.

TABLE XVIII.

Artemia in contaminated organic solutions.

Exp. No.	Solution (in sea water)	Contaminant	Maximum life span	Instar reached	Days to 3d instar	Days to 8th instar	Days to mating
A ₁₂ ²⁰	<i>Artemia</i> digest 1:10	very small spore former	19	5th	10	—	—
A ₁₄ ¹	yeast autolysate 1:20 1% dextrose	<i>Pseudomonas</i>	41	9th	10	38	—
A ₁₄ ²	yeast autolysate 1:20 5% glycerine	minute <i>Spirillum</i>	43	mature	11	19	43

The medium in which the bacterial contaminations occurred seemed to play no role in the growth or growth rate of *Artemia*, nor did the method of sterilization of the original solution seem to have any effect.

Later experiments of various sorts carried on in Schott aeration flasks gave much better growth when contamination occurred, which was probably the effect of the aeration by means of which the heavy growth of bacteria occurring was prevented from using up the oxygen or adding too much CO₂ to the solution. See Table XIX.

TABLE XIX.

Contaminated solutions in aeration flasks.

Exp. No.	Solution in sea water	Contaminant	Maximum life span	Instar reached	Days to 3d instar	Days to 8th instar	Days to mating
A ₈ ⁹	yeast autolysate 1:100 dextrose 1%	spore former	10	4th	4	—	—
A ₈ ¹³	do.	<i>B. danicus</i>	10	6th	5	—	—

Dead organisms. A considerable number of experiments was undertaken with various organisms killed by heat as a source of food for *Artemia*, but in no case was growth obtained. This result was hardly surprising as the organisms sank to the bottom at once where they were no longer available as food.

A device was therefore arranged by means of which such heat-killed protists could be kept in suspension by bubbling air through the liquid and still have the container remain free from contamination.

TABLE XX.

Artemia in heat-killed suspensions of various organisms—no living forms except *Artemia*.

Exp. No.	Food organism (pre-dominant)	% dissolved organic matter	Maximum life span	Instar reached	Days to 3d instar
A ₁₆ ⁴²	<i>Platymonas</i>	none	17	3d	13
A ₁₆ ⁴³	<i>Dunaliella viridis</i> (in 15% NaCl)	do.	2	1st	—
A ₁₆ ⁴⁴	<i>D. salina</i> (in concentrated brine)	do.	3	1st	—
A ₁₆ ⁴⁵	<i>Nitzschia</i> * <i>closterium</i> f. <i>minutissima</i>	do.	3	1st	—
A ₁₆ ⁴⁶	<i>Pseudomonas</i> sp.	do.	6	2nd	—
A ₁₂ ^{ac}	<i>Colpidium campylum</i> (.50% NaCl)	.06%	7†	3d	6
A _{ac} ³	do. (3.5% NaCl)	.06%	7	3d	5

*Strain obtained from Plymouth—aberrant culture form.

†Cotton plug accidentally knocked off and solution infected. This cult. stirred by air.

The device proved only partly successful, much less so than the Schott aeration flasks, but growth to the 3d instar was obtained with *Colpidium campylum* killed by heat and also with a (predominantly) *Platymonas* culture which was heat sterilized. See Table XX. In

the case of the ciliate the cotton plug was accidentally knocked out at this time and contamination occurred, so that it was impossible to make tests for sterility. The experiment was successfully repeated in a Schott aeration flask with *Colpidium* killed by the salinity of the medium. Here growth stopped after the 3d instar (5 days), and investigation showed that the dead ciliates had become autolyzed, or disintegrated through the mechanical action of the aeration, so that they were probably no longer fit for food for the *Artemia*, though it is possible that only limited growth can occur on dead organic matter.

Summary.—There is no doubt that *Artemia* can live on a very considerable diversity of particulate food, not only living, but also dead; and that the dissolved substances in the medium make little if any difference on the rate of growth. And it may, I think, be safely concluded that *Artemia* depends for its sustenance on particulate food alone.

EVIDENCE THAT ZOOPLANKTS INGEST AND DIGEST PARTICULATE FOOD.

Feeding mechanisms.—It has been seen that particulate food is necessary for the growth of *Artemia* and probably for other zooplankts. It therefore seems proper to consider briefly the methods used by various animals to obtain their particulate food; especially as this should throw some light on the feeding of the zooplankton in general.

Naumann (1918) gives a very careful and complete account of the food-gathering mechanism of the cladocera. Esterly (1916) does much the same for pelagic marine copepods, and Cannon for the ostracod, *Pionocypris vidua* (1926), for *Nebalia bipes* (1927), for the copepods *Calanus finmarchicus* and *Diaptomus gracilis* (1928), for the anostracan *Chirocephalus diaphanus* (1928), and (with Manton) for the syncarids (1929).

In all these forms particles in the water are swept backward by the outer ends of the appendages, then inward and forward between the mandibles, to the mouth where they are ingested. (The process in the copepods is slightly modified.)

In all these cases the swimming legs act as a most efficient straining and concentrating device. The exact amount of water filtered by these animals in a given time is not, however, known.

In the case of mosquito larvae the efficiency of the strainer has been determined. Senior-White (1928) using pure cultures of algae in which he placed anopheline larvae determined from counts that the larvae filtered all the organisms from 200 to 1000 cubic millimeters of water per day, according to age.

Lohmann (1908) showed that Appendicularia larvae are very efficient nannoplankton filterers, and that even the number of organisms caught but rejected is considerable.

Marie Lebour (1922) describes the successful methods of various coelenterates for capturing larval fish and crustacea.

In all these cases it should be noted that there is a complex and effective method of procuring particulate food. The argument is teleological, but it seems astonishing that such an apparatus should be found in forms which are nourished by dissolved matter. Such forms as *Opalina* and the tapeworms which are certainly users of dissolved foods possess no such mechanism.

Gut examinations.—Dakin (1908) in a study of the guts of copepods found that they contained comparatively few cells of phytoplankton.

Pütter (1909a, 1925) gives a good deal of weight to these findings, calculating that the organisms found are too few to account for the nourishment of these crustacea. He also quotes evidence to show that the gut contents of entomostracans are neither noticeably acid or alkaline, and appear to be lacking in any digestive ferments. Koehring (1930), however, states that "neutral red combines with enzymes wherever they exist in digestive lumina," and finds in *Daphnia* (as I found in planktonic copepods) that the lumen of the gut is the most rapidly stained portion of the body.

Observations on Artemia; Enzymes.—In the case of *Artemia*, moreover, it has been possible to demonstrate the presence of various specific enzymes. These experiments were not carried out in extenso, as the supply of *Artemia* on hand did not permit of it. The extract was prepared in each case by drying a living *Artemia* on filter paper; cutting off the appendages and genital processes with iridectomy scissors (and thus, incidentally, getting rid of the blood); and teasing the trunk of the animal with needles in 1 cc of 30% alcohol, with several drops of toluene. Extraction was allowed to continue for about 15 hours.

Proteases.—The method used was that of Pickford (1933). .02 cc. of extract was mixed with an equal quantity of buffer solution.

The drop of mixture obtained was put on the gelatine face of a prepared photographic plate, and allowed to remain (in a moist atmosphere to prevent drying) for 2.5 hours. At the end of this time the plate was fixed in formalin to prevent further digestion, and stained in hematoxylin to color the undigested gelatin. The pH range tested was 2. to 10. Complete digestion occurred at from 6. to 10.

There was practically complete digestion at 3. and at 5. Digestion was very slight at 4. and absent at 2. This may be taken to show either that two enzymes are present which are able to digest gelatine, one with an optimum pH of about 3., and the other with an optimum somewhere above 5., or that there is one enzyme which is inactive at its iso-electric point.

Amylase.—Five percent of rice starch was added to a solution of 1% agar and boiled for five minutes. The liquid was then strained through bolting silk, and poured out on a warmed glass plate in as thin a layer as possible, and allowed to cool. A drop of the extract was mixed with an equal quantity of buffer of pH 8. and placed on the starch plate. The slight opacity of the plate under the drop was completely reduced in 1 hour, and the difference could be emphasized by staining with Iodine and washing in running water for about 30 minutes. The control drop of buffer alone gave no effect whatever.

Lipase.—(The extract for this experiment was made from two *Artemia* in 1 cc. of alcohol, and digested for 24 hours.) The method used was the detection of the liberation of butyric acid from ethyl butyrate, litmus being used as an indicator. .15 cc. of extract, .15 cc. of tap water, a few grains of litmus powder, .2 cc. of neutral ethyl butyrate, and several drops of toluene were placed in a small test tube (internal diameter about 4 mm.), which had been drawn out into a thin neck about 3 cc. from the bottom. The neck was then sealed off in a flame without heating the rest of the tube, and digestion was allowed to take place in the sealed vessel, which was occasionally shaken. The litmus turned distinctly pink in about 10 hours, showing that the ethyl butyrate had been dissociated. The same experiment done with neutral cod-liver oil and with much less extract (.05 cc. with .2 cc. tap water and .2 cc. oil) showed scarcely any effect in 24 hours, though there seemed to be a very slight lightening of the blue as compared with that of the boiled control.

It can be seen, then, that there are at least one protease, an amylase and a lipase in *Artemia*. There perhaps exists the remote possibility

that these enzymes are of a purely intracellular nature, but this appears especially unlikely inasmuch as the *Artemia* trunks extracted were only teased and not ground up in the extracting liquid. Moreover, extracts of ordinary tissues made at such extreme dilutions (from 100–200 times as much liquid as original tissue) have not been found to give marked evidence of enzyme action.

Gut contents.—A considerable effort was made to study the gut contents of *Artemia*, but as far as actual statistics were concerned the results were very unsatisfactory, because it is nearly impossible to separate the fore from the hind part of the midgut, and because the cells of the gut epithelium tend to strip off and so confuse matters. Thus it was impossible to tell certainly (as Naumann did for cladocera) what is digested and what is not. However, some interesting observations were made.

By observation of living and dead *Artemia* it was found that:

1. Complete renewal of the gut contents takes place from 25 minutes to two and one-half hours, averaging about one hour.

2. Generally speaking, the more numerous the particles in suspension, the more rapid the renewal.

3. Inert particles are taken in as readily as living forms.

4. In a culture containing *Artemia* and *Platymonas*, large numbers of what appear to be the empty, cellulose (?) pellicles of the algae are to be found both in the flasks and in the guts of the *Artemia*.

5. These pellicles are lacking or very rare in fresh *Platymonas* cultures.

6. These objects are, however, to be found in fair numbers in the gut of *Artemia* which have been starved a few hours, and then put for two or three hours in such a culture.

7. Similar structures have not been identified either in the *Artemia* guts, nor in the flasks, in cultures of either *Dunaliella viridis* or *D. salina*. There is, however, an amorphous, rather hyaline substance.

8. As far as can be determined, in fresh cultures, the empty pellicles of *Platymonas* are more numerous in the posterior than in the anterior part of the *Artemia* gut.

9. In one culture of *Platymonas* a small percentage of the cells were producing spores or gametes (?) by internal division. In this case these pellicles containing small cells were the *only* cells with green pigment found in the hind third of the *Artemia* guts.

10. *Artemia* shaken vigorously in a flask (mechanically) for an

hour have almost empty guts, though the medium is rich in algae. If the shaking is done in a suspension of carmine, some will be ingested, but much less than when the suspension is undisturbed.

11. As far as can be told, *Artemia* feeds equally well in the light and in the dark.

The above observations may be interpreted to mean that *Artemia* ingests and actually digests large numbers of algal cells. The pellicles of the algae are not digested; in the case of *Platymonas* these keep their original shape, and are probably ingested over and over before they finally disintegrate. In the case of the thinner-walled *Dunaliella* the pellicle collapses and its shape can no longer be made out. In certain stages of the life history of *Platymonas* it becomes especially resistant to digestion. When *Artemia* is disturbed, it ceases almost entirely, at least for a time, to feed.

This last observation suggests that in certain forms—perhaps in Dakin's copepods—the handling incident to collection and preservation may cause them to cease feeding, so that unless the time before killing is made minimal, the loss through digestion and defecation will render the observations invalid. The suggestion has been made by others that since most collections are made by day, the copepods will usually be taken at depths well below the phytoplankton maximum, though the copepods approach the surface during the night and do the greater part of their feeding then.

Rapidity of renewal of gut contents of various forms.—Observations were therefore made on a number of forms to see how rapidly the guts were filled and emptied. A suspension of carmine in the medium was used. The results are shown in the following Table XXI.

TABLE XXI.

Times taken in filling guts of various animals. Time for emptying about 90% is the same as for filling. Traces of the gut contents may remain some time longer.

SPECIES	OBSERVED TIMES	APPROXIMATE AVERAGE
<i>Daphnia magna</i>	20 min.—1 hour 10 min.	55 minutes
<i>Daphnia pulex</i>	17–40 minutes	25 minutes
<i>Daphnia longispina</i>	12–48 minutes	15 minutes
<i>Daphnia thompsoni</i>	5– 9 minutes	7 minutes
<i>Daphnia galeata</i>	3– 7 minutes	4 minutes
<i>Branchinecta occidentalis</i>	about 1 hour	
<i>Branchinecta lindahli</i>	about ½ hour	
<i>Apus</i> sp.....	about 5 hours	
Diaptomid copepod (African)....	20–40 minutes	½ hour

It will be seen that several of these forms, if collected in the field and examined an hour or so later in the laboratory, might—if they behave like *Artemia*—be found to have practically empty guts.

Esterly found very irregular results with his copepods. Sometimes *Calanus finmarchicus* would fill the gut in a few seconds, and sometimes not for four or five hours. His paper and that of Lebour add very greatly to Dakin's work on the copepods. They both list more varied and more numerous forms from the guts of a number of species than were observed by Dakin.

It may be pointed out that while it is perfectly easy to observe and even count naked cells which are undigested, after they are digested, or even after the pellicles are ruptured, there is to all intents nothing to see or to count. The disintegration probably takes place practically instantaneously. It is hard to imagine a partly digested *Paramecium*, for example.

Dipteran larvae.—Hinman (1930) says (p. 263):

"1. Intestinal examination of over 600 mosquito larvae of 17 different species, from a great variety of habitats, revealed the fact that larvae ingest any material small enough to be taken in through the mouth.

"2. A large proportion of the material ingested by the larvae apparently passes through the alimentary canal unchanged and hence cannot be regarded as food."

and (p. 240):

"From the author's observations the mouth brushes are not filtering structures but rather organs for driving material along with water into the buccal cavity. . . . Observations indicate that larvae are not selective in feeding but sweep a constant stream of water containing organisms and other materials into the intestinal tract. These materials are retained within the intestine, where digestion takes place, and at irregular intervals wastes are discharged, usually in large clumps. Apparently previous workers have not observed, or else not considered, the ingestion of a considerable quantity of water as of any significance."

Hinman appears to use "filter" in this case to mean 'keep out undesirable and larger organisms.' That the mouth brushes or anal sphincter or both act as a concentrating filter is perfectly obvious, or organisms would be no more frequent in the gut than in the medium.

In speaking of the diatoms found in the guts he examined, Hinman says (p. 244):

"These organisms, which supposedly play such an important role in the nutrition of small aquatic animals, were constantly encountered in the intestinal contents, but it is extremely doubtful if the digestive juices of the larvae would have any solvent action on these hard silicious shells."

It may be remarked that the diatom cell must be permeable somewhere to absorb its own nourishment—perhaps between the vales of the shell.

Hinman continues:

"Naturally many empty cells were observed, but undoubtedly they had been ingested in this condition.³⁶ In spite of the conclusion, reached by Wesenburg-Lund and supported by Senior-White, that diatoms are the principal source of food, the author agrees with the statement of Van Thiel, 'I hesitate, therefore, to attribute to diatoms a role of great importance as digestible food'."

To show how differently essentially similar observations may be interpreted, I append a quotation from Cavanaugh and Tilden (1930) concerning another aquatic dipteran larva, *Tanytarsus dissimilis*. They say (p. 85):

"It was found that in many instances the silicious walls of the diatoms were broken, which suggests that they are crushed by the mandibles of the creature. Unbroken diatoms which had passed well down into the intestine were practically empty, proving that *digestion of diatom cell contents takes place even when the wall is intact.*" (*Italics mine.*)

Summary.—It is perfectly obvious that zooplankts generally do ingest a considerable quantity of particulate matter, and that a large proportion of the ingested material is actually digested. This is certainly the case with *Artemia*, and as the feeding mechanism and the gut contents are essentially the same in the other forms discussed, it seems reasonable to conclude that the same holds true for copeopds, cladocera, mosquito larvae (despite Hinman), and the rest.

DISCUSSION AND SUMMARY.

It was pointed out in the Introduction to this paper that the train of arguments offered by Pütter has been shown to be unsatisfactory. But though Pütter's arguments to show that the zooplankton *must*

³⁶ From which it should follow that mosquito larvae are bottom feeders, or else that 'many empty cells' are suspended in the water.

feed on dissolved food have been shown not to hold, the question as to whether or not the zooplankton *may* so feed has been largely neglected. The experiments here reported were made in an investigation of this possibility.

A method more accurate than those hitherto reported was worked out for the determination of organic matter in sea water and in the marine plankton.

By means of this method the oxygen capacity (a function of the organically combined carbon) of the dissolved organic matter in sea water, of the nannoplankton and of the netplankton was determined. (The determinations were made on samples from East Sound, State of Washington. They extended over a period of about two months.) It was discovered that the nannoplankton approximately equalled the net plankton, and that the dissolved organic matter averaged only about 3.3 times the organic matter of the total plankton. Since Krogh and others have shown that the final products of the decay of organic matter found dissolved in natural waters is assimilated with some difficulty, even by bacteria, it is concluded that in effective food-value, especially for the metazoa, the particulate organic matter greatly out-weighs the dissolved.

For this reason, a considerable study of the particulate food supply in natural waters was undertaken. Evidence from the literature was brought forward to show that the nannoplankton is often extraordinarily numerous. Experiments appeared to show that certain types of dissolved organic matter (even in minute quantities), may greatly increase the rate of reproduction—and therefore the food-value—of a number of phytoplankts. The food requirements of the ciliate, *Colpidium campylum* were investigated. It was found to grow on solutions of protein breakdown products containing the equivalent of as little as .015% protein. Its growth rates in various dilutions of medium were determined, and something of the nature of the nitrogen and carbon compounds it could assimilate. Similar experiments were made on certain single-celled algae.

Before undertaking actual experiments on the feeding of zooplankts, some consideration was given to their permeability. Experiments reported by previous workers show that most marine invertebrates and some fresh-water forms are permeable, probably through the chitinous integument, at least in part. Experiments appear to show that the brine shrimp, *Artemia* sp., is permeable to some degree.

Thus there is no theoretical reason why marine invertebrates (and *Artemia*) should not be able to absorb dissolved foods through the integument.

The literature on the use of dissolved foods by the zooplankton is touched upon, and the shortcomings of the experiments (both cited and original) are pointed out. The most probable source of possible error lies in the failure to consider bacteria as a particulate food.

In order to eliminate the possible effect of bacteria, a series of experiments was undertaken under sterile conditions. Eggs of *Artemia* were sterilized with HgCl_2 , and the sterile nauplii were placed in a large number of different "nutrient" solutions, natural and made up; and sterilized, some by autoclaving and some by filtration. In no case did the nauplii grow. Experiments, by means of analysis of the medium, on the utilization of dissolved dextrose gave negative results.

In a series of experiments on the use of particulate food by *Artemia*, it was found that normal growth occurred when any one of several unicellular algae was furnished. Growth was also obtained on single and mixed strains of bacteria, purposely introduced with a minimum of dissolved organic matter, or present as contaminants in the organic solutions of the first series. The *Artemia* also grew on *Colpidium campylum*, both living or dead. It is therefore concluded that *Artemia* is entirely dependent on particulate matter for its food. These facts suggest that the same is true for the other zooplankton.

Finally a survey is given of what is known of the food-gathering and ingesting methods of various zooplankts. These methods are usually very efficient, and would appear to be adaptations to particulate rather than to parenteral feeding.

Protease, amylase, and lipase were demonstrated in the gut of *Artemia*, and observations of the gut contents of this animal show that algae ingested are actually digested. Experiments on various forms suggest that the empty, or nearly empty guts sometimes previously reported may be caused by rapid digestion and elimination of the gut contents, and a cessation of feeding after the animals have been collected and before they were examined.

The question of the feeding of the zooplankton may be summarized as follows:

1. *Artemia* (the only zooplankt so far investigated with equal care) is dependent upon particulate food.

2. The nature and amount of dissolved and particulate foods in natural waters, and of the filtering and predatory devices of the animals, makes it seem extremely unlikely that dissolved organic matter plays any important part in the natural nourishment of the marine zooplankton.

3. Any seeming correlation between the quantities of dissolved organic matter and the zooplankton must, in reality, be of an indirect nature, with the phytoplankton, and especially the nannoplankton as intermediary stages.

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A REVISION OF THE GENUS GOBIOSOMA (FAMILY GOBIIDAE)

WITH AN ACCOUNT OF THE GENUS GARMANNIA.¹

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INTRODUCTION

The present report is concerned chiefly with the scaleless gobies belonging to the genus *Gobiosoma*, some of the species of which are exceedingly common on the east coast of the United States, both on the Atlantic Coast as well as on the coast of the Gulf of Mexico.

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Being very common they necessarily must play an important role in the complex interrelationship of the littoral marine fauna; and yet, altho very common, the separation of some of the species has not been satisfactorily established heretofore; whereas, after the specific characters are worked out in detail, it becomes a comparatively easy matter to distinguish the species, as the data presented below will prove. A brief account of *Garmannia* is also given in order to show its relationship to *Gobiosoma*.

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HISTORICAL REVIEW

Systematists have generally regarded the naked gobies of the Atlantic and Gulf coasts of the eastern United States, as belonging to two species, one species being regarded as confined to the Atlantic Coast and the other as occurring on the coast of the Gulf of Mexico. The historical development of our knowledge regarding the common species of the east coast may be sketched briefly as follows: The first account of a scaleless goby from the coast of the United States, which is known to me, is that by Lacepede (1800) who published a

description from Bosc's manuscript, based on specimens from South Carolina designating the species as *Gobius bosc.* Bloch and Schneider (1801) renamed the same species *Gobius alepidotus*, their account being based on that of Lacepede; their name, evidently regarded as more appropriate, being Bosc's manuscript name, according to Lacepede's account. Mitchil (1815) described a species of naked goby, based on specimens from New York, designating it *Gobius viridipallidus*. Cuvier and Valenciennes (1837) synonymized the above three early names and used the name *Gobius boscii* for the Atlantic Coast naked gobies, thus intimating that only one species exists on the Atlantic Coast, and, also, supplying a Latin ending to Lacepede's name. Authors immediately following Cuvier and Valenciennes, namely, De Kay (1842), Linsely (1844), and Baird (1855), recorded naked gobies from New York, Connecticut, and New Jersey, respectively, as *Gobius alepidotus*. Girard (1858) described what purported to be a second species of naked goby from the United States based on a single specimen from Texas, establishing the genus *Gobiosoma* to include the naked gobies and designating the new species as *Gobiosoma molestum*. Gunther (1861) recognized two species of *Gobiosoma* from the east coast of the United States, *G. molestum* from Texas, his account being based on that of Girard, and *G. alepidotum* from the Atlantic Coast, the given synonymy of the latter being the same as stated by Cuvier and Valenciennes. Authors immediately following Gunther, who mentioned naked gobies from the east coast are, Putman (1874) recording *Gobiosoma molestum* from Louisville, Kentucky, the locality being evidently erroneous; and Uhler and Lugger (1876) who recorded *Gobiosoma alepidota* from Maryland. Jordan and Gilbert (1882) in the body of their "Synopsis" (Bull. U. S. Nat. Mus., No. 16, p. 638), like Gunther, designated the naked gobies of the "South Atlantic Coast of the United States" as *Gobiosoma alepidotum*, giving *boscii* as a synonym; while *G. molestum*, based on Girard's account, is recognized from Texas. However, a little later (Pr. U. S. Nat. Mus., vol. 5, p. 297, 1882; evidently written later than the Synopsis, altho apparently published a little earlier in that year), the same authors, recording naked gobies from Pensacola, Fla., state: "We are unable to distinguish our specimens from *G. alepidotum* from the Atlantic Coast." They use the name *Gobiosoma alepidotum* for the Pensacola fish, and *G. molestum* is placed in synonymy, thus evidently concluding

that there is only one species of naked goby which is distributed on the Atlantic and Gulf Coasts. In the addenda to the Synopsis (p. 948) the name *bosci*, having priority, is substituted for *alepidotum*, with the name *molestum* again placed in synonymy. These authors then continued to record the naked gobies under the name of *G. bosci*; Jordan and Gilbert (1883, Charleston, S. C.), Jordan (1884, Key West, Fla.), Jordan (1884, Indian River, Fla.), Jordan (1886, Beaufort, N. C.). Jordan and Eigenmann (1886) revert to the ideas of Gunther and that of Jordan and Gilbert in the body of their Synopsis, and recognize two species, *molestum* from the Gulf and *bosci* from the Atlantic, stating, however, that "a full series of specimens will doubtless show intergradations . . . at the most *G. molestum* is probably only a southern representative or variety of *Gobiosoma bosci*." Eigenmann and Eigenmann (1888) and later authors, including Jordan and Evermann (1898), have continued to treat the naked gobies of the east coast as belonging to two species, recording specimens from the Atlantic Coast under the name of *bosci* and those from the Gulf as *molestum*, with the exception of Evermann and Kendall (1894). Jordan and Dickerson (1908), like Jordan and Gilbert (1882), by a comparison of specimens from the Atlantic and Gulf Coasts, have come to the conclusion that, "the two species, *G. bosci* and *G. molestum*, are one and the same," thus intimating that only one species of naked goby exists on the east coast; but this action is reversed for the fourth time by Jordan, Evermann, and Clark (Rep. U. S. Comm. Fish., 1928, pt. 2, p. 446, 1930) who again recognize two common species, one on the Atlantic Coast and one in the Gulf, designating them as *bosci* and *molestum*, respectively.

It should be noted particularly that the conclusion of Jordan and Dickerson (1908) as well as that of Jordan and Gilbert (1882) pertains not merely to a solution of a nomenclatorial problem, whether the name *molestum* is a synonym of the name *bosci* or *alepidotum*, a proposition which happens to be correct, as shown below. Evidently, their conclusion is primarily zoological, that only one common species of naked goby exists on the east coast thus necessitating the use of the oldest available name and the reduction of other names to synonymy. This proposition is thoroly disproven in the present account.

The vacillation in the taxonomic treatment of these common species under consideration is really not as strange as it may appear. After the true state of affairs has been revealed by the present study one

can readily visualize the reasons for this indecision. It will be shown below that on the Atlantic as well as on the Gulf Coast, at least two common species occur together, *bosci* and *ginsburgi* in the Atlantic and *bosci* and *robustum* in the Gulf. (In southern Florida three, and possibly more, species may occur together, the range of *bosci* being continuous from Long Island to Mexico, that of *robustum* extending northward at least to the Indian River on the east coast of Florida, *longipala* being known from one specimen from southern Florida and *longum* also occurs at the Florida keys, while *ginsburgi* may possibly extend to southern Florida, altho the southern limit of its range as now established is South Carolina.) On the other hand, after a comprehensive review of the literature, one can not help but be impressed with the thought that to most workers with these fishes the problem generally revolved itself around the idea as to whether the common naked gobies are to be divided into two species, a "northern" and a "southern" one, or whether they are not so divisible. Furthermore, while after an extensive, comparative study has been made, it becomes an easy matter to distinguish the species, they are very similar in general appearance, and superficially appear to belong to one species. The uncertainties hitherto existing in regard to the status of the species were then due to their close resemblance and accepted erroneous ideas or an imperfect knowledge of their distribution. What was needed was a frequency distribution study and correlation of the meristic differentiating characters. The data for such a study are given in the present revision.

The preceding paragraphs summarize the prevailing ideas regarding the common naked gobies and the successive changes in the accepted ideas. It was shown that if a naked goby was collected on the Atlantic Coast it was generally recorded under the name of *bosci* or one of its synonyms, while if one was collected on the Gulf Coast it was generally designated as *molestum*, with the exception of two publications in which all naked gobies of the east coast were regarded as belonging to one species. Four other exceptions should be noted. Of the many references which have been consulted, in only two publications a complete and correct treatment of the naked gobies of the east coast, concerning the particular localities under consideration, was given; namely, Hildebrand and Schroeder (1928) by a comprehensive study of material showed that two distinct species exist in Chesapeake Bay, while Evermann and Kendall (1894) correctly

recognized two species from Texas, altho they did not define their species. In two other papers, Evermann (1899) records *bosci* from Mississippi, and Fowler (1917) records naked gobies under that name from Boca Grande, Florida; but it is not evident whether these authors use that name because they then regarded all naked gobies from the east coast as one species to which they applied the oldest available name, or whether they distinguish two species from the Gulf Coast.

The unsatisfactory treatment which the species of *Gobiosoma* hitherto received in nearly all cases may be further impressed forcibly by the following numerical summary of the records in the literature. Altogether 50 publications by various authors dealing with the common naked gobies of the east coast, have been consulted. Of these papers one recording a goby from Louisville, Kentucky (Putnam, 1874), is evidently in error in regard to the given locality. The other 49 may be divided into two categories, one showing the general trend of ideas regarding the species and the other forming exceptions to the general trend. The 6 exceptions as well as some of the others are discussed in the preceding paragraphs. It is to be noted further that in the larger category containing the bulk of publications, 43 out of 49, representing the prevalent ideas in regard to these gobies, 41 records relating to fishes from the Atlantic Coast have been designated invariably as *bosci* or its synonyms *alepidotus* and *viridipallidus*, and 7 relating to specimens from the Gulf Coast have been designated as *molestum*; 5 of the 43 publications recording 2 species. It is significant to note especially that none of these 43 references record two species as occurring at any one given locality. Nevertheless, the present study has shown unmistakably that at nearly every point on the coast from Long Island to Texas, from which collections are available, at least two common species occur. Consequently, the aggregate of the material on which these records in the literature are based, surely must have represented more than one species on the Atlantic Coast and more than one on the Gulf Coast, species which, as shown hereafter, may be distinguished by definite morphological and color differences. As a matter of fact, altho but few of the specimens on which the records in the literature are based have been reexamined, in one case at least they were found to be a composite of two species. Considering the fact that the species are so common that specimens may be obtained almost any day by pulling a small seine in the proper places, it would be strange, indeed, not to find

many more like cases, if more recorded specimens would be reexamined. The inevitable inference is evident, namely, the species have been largely separated on geographical lines rather than by morphological differences.

The new species discovered as a result of this study, herewith reported in detail, were published in a preliminary paper (Pr. U. S. Nat. Mus., vol. 82, art. 20, 1933), which is mentioned here in order to complete the historical review of the extant literature on the common species of the east coast; but is left out of the preceding discussion, since that paper is in reality a part of the present study. The status of the other species of the genus is not so involved and the history of each species is sufficiently indicated in the synonymy and the given account.

NOMENCLATURE OF THE SPECIES

Those conversant with current works on American fishes will miss the familiar name *molestum* which has been used for a species of naked goby from the Gulf Coast of the United States. That name is placed in the synonymy of *bosci* as suggested by me in a preliminary paper, cited in the preceding paragraph. The reason for this action as well as discussions of the nomenclature of the species about the legitimate names of which there may be some doubt are given below (pp. 34 and 41). Briefly anticipating some of the conclusions arrived at as a result of this revisional study and described in detail under each species, in order to make more intelligible the paragraphs immediately following, it may be pointed out that three common species occur on the east coast of the United States as follows: *ginsburgi* ranging from Massachusetts to South Carolina, *bosci* ranging from Long Island to Mexico, and *robustum* ranging from Florida to Brazil.

MORPHOLOGICAL DIFFERENCES BETWEEN THE THREE COMMON EAST COAST SPECIES

The fact that the three common species have been confused generally, shows that superficially they must have a close resemblance, as stated. Nevertheless, when a detailed study is made of some of the characters usually employed in separating closely related species they are found to show well defined differences in the frequency distribution of these characters, as follows.

NUMBER OF DORSAL RAYS: The difference in the number of soft rays in the second dorsal is very useful in distinguishing the common species since it shows marked divergence. From the frequency distribution of that character (Table 1) it may be seen that the fishes fall into two well defined groups, one group with a modal number of 12 rays and another group having a modal number of 13. Moreover, both groups occur in the Gulf as well as on the Atlantic Coast showing that this difference can not be correlated with geographic distribution. The group modally having 12 rays consists of two species, *ginsburgi* and *robustum*, which may be further differentiated by other characters, while that having 13 rays represent *bosci*. In counting the soft rays, the first unbranched and simple ray was included, while the last two which are approximated at their base have been counted as one.

TABLE 1.—Frequency distribution of the number of rays in the second dorsal. The first simple ray was included in the count while the last two which are approximated at their base have been counted as one.

Species and locality	Number of dorsal rays			
	11	12	13	14
<i>ginsburgi</i> (Chesapeake Bay)		23	5	
<i>ginsburgi</i> (Massachusetts)		7	1	
<i>ginsburgi</i> (South Carolina)		5		
<i>robustum</i> (Gulf coast)	7	20		
<i>robustum</i> (Cocoa, Florida)	3	5	1	
<i>bosci</i> (Gulf coast)			17	2
<i>bosci</i> (Atlantic coast)		4	20	3

THE RELATIVE LENGTH OF THE VENTRAL FIN

The relative length of the ventral fin is another character which corroborates the preceding one, the two characters showing a close correlation; the group modally having 12 rays and consisting of two species, as stated, also has a relatively long ventral, while that modally having 13 rays also has a markedly short ventral. In employing this character it should be noted that the ventral length varies with age to a considerable extent, being relatively longer in the smaller specimens. However, an inspection of my rough data shows that in specimens 30 millimeters or more in standard length the difference due to age is not sufficiently pronounced to mask that due to specific divergence, and data from specimens of such sizes only were used in

the tabulation. Table 2 giving the frequency distribution of this character corroborates the conclusions drawn from Table 1; the combination of these two characters, making possible the separation of *bosci* from the two other species. Table 3 shows the latter character in a different way, the relation of the ventral length to the distance from its base to the origin of the anal. This has been prepared chiefly to show the divergence of *longipala* which is known from but a single specimen.

TABLE 2.—Frequency distribution of the length of ventral fin, expressed as a percentage of the standard length. Only specimens of 30 mm. or more in standard length have been included. The heading numbers represent the mid-values of their respective classes; for instance, class 17 is the same as 16.5–17.4.

Species and locality	Length of ventral % of body length									
	17	18	19	20	21	22	23	24	25	26
<i>ginsburgi</i> (Atlantic coast)					4	5	4	5	4	1
<i>robustum</i> (Gulf coast)				1	2	3	3	2		
<i>robustum</i> (Cocoa, Florida)				1	1	1		1		1
<i>bosci</i> (Atlantic coast)	1		5	2						
<i>bosci</i> (Gulf coast)	1		7	2						

TABLE 3.—Frequency distribution of the length of the ventral as measured by the numerical value of the ratio of the distance from its base to the origin of the anal, to its length. Only specimens of 30 mm. in standard length or more have been included in this study.

Species and locality	Length of ventral in the distance from its base to origin of anal										
	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
<i>longipala</i> (Boca Grande, Fla.)	1										
<i>ginsburgi</i> (Atlantic coast)			2	8	7	5					
<i>robustum</i> (Gulf coast)			2	6	1	2					
<i>robustum</i> (Cocoa, Florida)			1	1	1	2					
<i>bosci</i> (Atlantic coast)									6	1	1
<i>bosci</i> (Gulf coast)							2	4	2	1	

THE RELATIVE DEPTH: Having segregated *bosci* in a general way by the correlation of more numerous dorsal rays and a shorter ventral disk, the residue of the material, representing the other two common species, may be seen at a mere glance to fall into two groups divisible by the relative depth of the body. This residue, as noted, has the

combination of a relatively longer ventral disk with a modal number of 12 dorsal rays. When such specimens from the coasts of Texas and Louisiana are compared with those from Chesapeake Bay, for instance (the localities at which the bulk of the specimens examined were obtained), there appears a striking difference in the form of the body. The Gulf specimens are markedly stocky while the Chesapeake Bay specimens are conspicuously more slender. The difference in the appearance of the fish is such as to suggest two distinct species, altho there is a certain amount of overlapping. The deeper species is *robustum* and the more slender one *ginsburgi*. A convenient numerical expression of this character is the relation of the greatest depth of the body, and the least depth of the caudal peduncle to the standard length, expressed as percentages of the latter.

GREATEST DEPTH OF THE BODY: This character depends to a large extent on the state of the specimen with reference to the quantity of food present in the stomach at the time of its preservation. Some specimens are gorged with food in which case the belly is greatly distended and subglobular. It is evident that to compare such specimens with those in which the belly is normal will not give a true picture of the specific difference. Therefore, only such specimens in which the belly appears normal have been tabulated. The same will hold in the case of specimens abnormally distended with ripe gonads. Also, in order to minimize the influence of the size of the fish on the relative depth (see succeeding paragraph), only specimens of 20 mm. or more in standard length have been included in the table. An inspection of Table 4 will show that there is a very marked difference

TABLE 4.—Frequency distribution of the greatest depth of the body expressed as a percentage of the standard length. Specimens gorged with food and those under 20 mm. in standard length have been excluded from tabulation. The class numbers refer to their mid-values as in Table 2.

Species and locality	Greatest depth of body, % of standard length											
	17	18	19	20	21	22	23	24	25	26	27	
<i>ginsburgi</i> (Atlantic coast)	1	3	3	9	2	2						
<i>robustum</i> (Gulf coast)						1	1	3	4	2	2	
<i>robustum</i> (Cocoa, Florida) ¹						5	1	1	2			
<i>bosci</i> (Atlantic coast)					1	1	5	1	1			
<i>bosci</i> (Gulf coast)					1	1	5	2	3			

¹ Small specimens only, ranging 25 to 32 mm. in standard length.

in the modes of *ginsburgi* and *robustum*, altho there is some overlapping. In *bosci* the depth is more nearly like that in *robustum* and there is no difference between specimens of *bosci* from Chesapeake Bay and those from Louisiana and Texas.

LEAST DEPTH OF THE CAUDAL PEDUNCLE: It seems reasonable to expect that the relative depth of the caudal peduncle to the standard length will vary with the size of the fish. However, an inspection of my preliminary tabulated data shows that in these species the form of the adult is assumed when the fish is quite small. There is not much difference in the relative depth with regard to size, after the fish reach a standard length of 20 millimeters. The small average difference which may be due to size is evidently not sufficiently pronounced to hide the specific divergence. This is also true with respect to the preceding measurement, namely, the greatest depth of the body. Table 5 gives the relative measurements of the depth of the caudal peduncle in specimens of 20 millimeters or more. It is to be noted that the difference between *ginsburgi* from Chesapeake Bay and *robustum* from the Gulf coast is considerable, although the divergence is not as great as in the case of the greatest depth. In the case of *bosci*, there is also a measurable difference between those from the Gulf and those from the Atlantic, but this difference is not striking, and the degree of difference is evidently more of a racial nature than of specific importance. The difference in *bosci* may also be due to the small numbers which have been measured.

TABLE 5.—Frequency distribution of the least depth of the caudal peduncle, expressed as a percentage of the standard length. Only specimens 20 mm. or more in standard length have been tabulated. The class numbers refer to their mid-values as in Table 2.

Species and locality	Least depth of caudal peduncle, percentage					
	11	12	13	14	15	16
<i>ginsburgi</i> (Atlantic coast)	6	14	11	4	2	
<i>robustum</i> (Gulf coast)				2	7	4
<i>robustum</i> (Cocoa, Florida) ¹			6	3		
<i>bosci</i> (Atlantic coast)			4	6	2	
<i>bosci</i> (Gulf coast)			1	2	6	4

¹ Small specimens only, ranging 25 to 32 mm. in standard length.

THE NUMBER OF ANAL RAYS: Corroborative of the conclusions based on a study of the foregoing characters, is the manner of the

frequency distribution of the anal rays given in Table 6. In this character the frequency distribution of *robustum* is markedly different from *ginsburgi*, the mode in the former species being distinctly at 10, while in the latter the mode is 11. There is hardly any difference in specimens of *bosci* from both coasts and the number in this species is nearly the same as in *ginsburgi*. The same method of counting the rays was used as in the case of the dorsal.

TABLE 6.—Frequency distribution of the number of rays in the anal fin. The first simple ray has been included in the count, while the last two which are approximate at their base have been counted as one.

Species and locality	Anal rays		
	10	11	12
<i>ginsburgi</i> (Atlantic coast)	7	31	1
<i>robustum</i> (Gulf coast)	23	4	
<i>robustum</i> (Cocoa, Florida)	8	1	
<i>bosci</i> (Atlantic coast)	1	21	4
<i>bosci</i> (Gulf coast)	2	16	2

SCALES AT THE BASE OF THE CAUDAL: From the foregoing data it is evident that *bosci* may be readily separated from *robustum* and *ginsburgi* by two well marked structural divergences. The structural differences are reinforced by a difference in the typical color pattern, as pointed out in the accounts of the species. However, the latter two species, while showing marked differences in the mode of the characters investigated, also show more or less intergradation. The color pattern is also very similar in the two. In casting about for some character which will more satisfactorily distinguish the two evidently valid species, there was discovered one constant structural difference between them, as follows. In *ginsburgi* there are two strongly ctenoid scales on the caudal fin, at its base, one near the upper edge, and one near the lower; while *robustum* lacks these scales. This character is not a matter of degree; it is evidently absolute. In *ginsburgi* and the related species the scales are always present, while in *robustum* as well as in *bosci* and their near relatives, they are always absent. This striking and constant character forms the basis of the new subgenus *Dilepidion* established in the preliminary paper cited above.

The data tabulated and discussed in detail in the preceding para-

graphs prove without a doubt the distinctness of the three common species from the east coast of the United States. Individual fish may be definitely placed by the use of these structural differences, with very few exceptions, sometimes specimens being encountered which may be doubtfully referred to either *bosci* or *robustum*. Most of the few doubtful specimens, as far as structural differences are concerned, may be placed with assurance by differences in the typical color pattern, as pointed out below. Having definitely distinguished the species and properly segregated the material by species, the distribution of the separate species thus revealed shows that the prevailing ideas in regard to the geographical distribution of the common naked gobies are quite erroneous. The ranges of the species overlap widely, and they can not at all be differentiated along geographical lines. After having thus definitely distinguished the three common species, we may now proceed to a revisional account of the entire genus.

GENERIC LIMITS

It is difficult to decide on the proper limitation of the genera to which the species treated herewith are to be assigned. The best character for generic separation, known at present, is the scalation; and that character may be discussed in some detail. I believe that all ichthyologists will agree that typical species of *Gobiosoma* which entirely lack scales should be generically separated from those in which the body is covered with scales, as for instance, those gobies which are currently placed in *Aboma*. If this distinction is disregarded we might as well discard to a large extent generic division among gobies and treat most of them as belonging to one genus. However, while it may be agreed generally that the species at either extreme be placed in separate genera on the basis of this difference in scalation, it should be noted that *Garmannia* is exactly intermediate in this respect. Furthermore, the present study has shown that there is almost a complete and gradual transition from *Aboma* thru *Garmannia*, to *Gobiosoma*. Thus, in *Aboma* the body is entirely covered with scales, in *Garmannia paradoxa*, the genotype, the scales are present only on the posterior half, from a line somewhat behind the origin of the second dorsal; in *Tigrigobius* (established originally as a subgenus of *Gobiosoma*) the scales are still further reduced to a small patch on the caudal peduncle, and four scales on the caudal fin at its

base (these four scales being present also in *Garmannia*); in *Gerhardinus* as well as *Dilepidion* the scales are reduced to a minimum, to two and two only, on the caudal fin, at its base, one above and one below, no scales being present on the body or caudal peduncle. The final step leads to typical species of *Gobiosoma* in which no scales at all are present, neither on the body nor on the caudal. The foregoing sketches in broad lines the gradual transition from one genus to the other, as far as the known species are concerned; it is also reasonable to expect that when the number of known species increases, the progressive continuity from the scaleless to the fully scaled condition, in this group of gobies, will become even more striking.¹ It is true that the scalation is quite constant intraspecifically, but where is the line to be drawn to differentiate the genera? It is apparent that there is room for difference of opinion in regard to generic division in this case, as indeed, there may be in many similar cases. It seems to me that in such cases, convenience is to be a deciding factor. The course adopted in the present paper, is to treat the more detailed changes in scalation and in other characters, as of subgeneric value; and to draw a more or less arbitrary line between the genera. *Gerhardinus* and *Dilepidion* are thus recognized as subgenera of *Gobiosoma*, while *Tigrigobius* is made a subgenus of *Garmannia*. In this way the relationship of the species is fully shown; while the nomenclature of the species, that is as far as it concerns the names of the species as they are to be in actual use by biologists, is freed from being cluttered up with a great array of generic names. It may be added that this treatment is not entirely arbitrary; there are other characters which support this arrangement as pointed out under the account of *Garmannia*.

GOBIOSOMA²

DEFINITION: Scales entirely absent or two ctenoid scales present on caudal fin at its base (in the subgenera *Dilepidion* and *Gerhardinus*).³ Dorsal spines normally 7 (in 123 specimens), infrequently 8 (in 4), rarely 6 (in 1 fish; the number of specimens stated being the total

¹ After the above was written a new species was discovered which evidently still further narrows the gap between *Gobiosoma* and *Garmannia* (see account of *Gobiosoma parri*, p. 44).

² For synonymy and genotype see p. 27.

³ See also account of *G. parri*, p. 44, which probably has four scales on the caudal in the adult.

counts made, including all the species). Number of rays in second dorsal 11 to 14, those of anal 10 to 13; the dorsal normally having 1 or 2 rays more than the anal, sometimes 3 more. (Except in the subgenus *Elacatinus* in which individuals having the same number of rays in both vertical fins are frequent. In a combined count of 153 individuals of the other species the dorsal, with the exception of a single specimen, had at least one ray more than the anal). Teeth in both jaws in bands, the outer row of both jaws enlarged (except in the lower jaw of *Elacatinus*); inner row of lower jaw, and in some species also inner row of upper jaw, having enlarged teeth. Tongue entire or emarginate (in *Aruma*). First spine of anterior dorsal not prolonged, rather shorter than the following spines (except in the subgenus *Nes*). Maxillary moderate, usually not extending past a vertical through posterior margin of eye, or but slightly past that. Shoulder girdle without flaps of skin. All pectoral rays connected by membrane. Ventrals free, not adherent to belly, well developed, completely united; interspinal membrane well developed. Caudal rather short, rounded or truncate. No long barbels; one barbule-like flap of skin in front of eye, at inner edge of upper lip more or less developed or absent. A small frenum extending backward from lower lip, often indistinct in preserved specimens, bilobed in one subgenus (*Gerhardinus*), the lobes resembling barbules. Cutaneous papillae on cheek in transverse as well as longitudinal rows; two rows on under side of head along lower jaw, continued upward along posterior edge of preopercle, the inner row of these two more or less enlarged; a row on upper jaw along inner margin of upper lip, from angle of mouth curving anteriorly towards eye; a vertical row on opercle along its anterior margin and two transverse rows, one above and one below; a longitudinal row over upper edge of opercle; a transverse row behind eye, more or less interrupted; a series of short transverse rows along middle of body; other smaller groups of papillae on nape, on snout and behind or over base of pectoral.

REVIEW OF THE SPECIES WHICH HAVE BEEN PLACED
IN GOBIOSOMA BY VARIOUS AUTHORS

The genus as here defined and limited is confined to the American continents, the known species on the east coast ranging from Cape Cod, Massachusetts, to Pocitos, Uruguay, including the West Indies; while on the west coast they are found from the Gulf of California

to Paita, Peru. Extralimital scaleless gobies which have been placed in *Gobiosoma* from time to time by various authors do not belong to it, as follows. *Gobius diadematus* Rüppel from the Red Sea was placed by Gunther (Cat. Fish. Brit. Mus. vol. 3, p. 85, 1861) in *Gobiosoma*. This author, however, did not have any specimen. The species was redescribed by Klunzinger (Syn. Fisch. Rothen Meeres, pt. 2, p. 483, 1871) as having the ventrals separated, which proves that it can not belong to the present genus. It was later placed in a distinct genus, *Heteroleotris*, by Bleeker (Arch. Neerland. Sc. Nat., t. 9, p. 306, 1874). For the same reason the species described by Klunzinger as *Gobiosoma vulgare* (l. c., p. 484) does not belong to this genus. The European species doubtfully placed by Gunther (l. c., p. 86) in *Gobiosoma*, namely *nilssonii* and *stuvitzii*, have since been allocated, with ample reason, to distinct genera, the latter species which was erroneously described as lacking scales, having been placed by Gunther himself (l. c. p. 80) under another name, in a distinct genus, *Latrunculus*. For a synonymy of these two species see De Buen (Notas y Resúmenes, Inst. Esp. Ocenogr. ser. 2, no. 54, pp. 3 and 15, 1931). *Gobiosoma caspium* Kessler from the Caspian Sea (Trudy Aralo-Kaspiskoi Ekspeditsii, Ryby, p. 38, fig. 9, 1877) was recently placed in a distinct genus, *Caspiosoma*, by Iljin (see Trabajos Inst. Esp. Oceanogr. No. 2, p. 57, 1930). *Gobiosoma fasciatum* Playfair (Fish. Zanzibar, p. 72, 1866) was later made the type of the new genus, *Alepidogobius*, by Bleeker (l. c., p. 310). *Gobiosoma insigne* Herre and *Gobiosoma marmoratum* Peters (see Herré, Gob. Philippines, pp. 289-291, 1927) do not belong to *Gobiosoma* as limited in this paper, since they have 6 dorsal spines, whereas the species of *Gobiosoma* pretty constantly have 7 spines, except as an infrequent individual variation. These two latter species probably belong either to *Alepidogobius* Bleeker or to *Kellogella* Jordan and Seale, more probably the latter (see p. 18 for a discussion of the relationship of the genus *Kellogella*). The latter two genera of naked gobies have 6 dorsal spines and comparatively few fin rays. As far as may be judged from descriptions *Alepidogobius* differs from *Kellogella* in the filamentous condition of the first ray of the spinous dorsal, but other characters may be revealed on direct comparison of material. *Gobius ophicephalus* Jenyns (Zool. Voy. Beagle, p. 97, pl. 19, fig. 3, 1842), a naked goby from the coast of Chile, which has been placed by Gunther (l. c., p. 86) in *Gobiosoma*, was later made the type of a new genus,

Ophiogobius, by Gill (Pr. Ac. Nat. Sc. Philadelphia, p. 269, 1863). This species was redescribed by Steindachner (Fauna Chil., bd. 1, p. 306, 1898), and its probable relation to *Gobiosoma* is indicated below. For other, American, species originally placed in *Gobiosoma* but later referred to other genera see Jordan, Evermann and Clark (Rep. U. S. Comm. Fish., 1928, pt. 2, pp. 445 and 446, 1930). Of two American species omitted by these authors altho coming within the geographical limits of their purview, namely, *Gobiosoma pantherinum* and *G. digueti* Pellegrin (Bull. Mus. Hist. Nat. Paris, t. 7, p. 165, 1901), from the Gulf of California, the former is described as having barbels and is evidently not a member of *Gobiosoma*, probably belonging to *Barbulifer* Eigenmann and Eigenmann (Pr. California Ac. Sc., ser. 2, vol. 1, p. 70, 1888); while the probable position of the latter is indicated below (see p. 55). *Gobiosoma crescentale* Gilbert another species from the Gulf of California was but recently placed in a distinct genus *Gobulus* Ginsburg (Pr. U. S. Nat. Mus. vol. 82, art. 20, p. 12, 1933). Finally, a species from the West Indies, *Gobiosoma macrodon* Beebe and Tee-Van, is here allocated to *Garmannia* (see p. 53). As a result of the foregoing review of the literature, it may be stated that this revision of *Gobiosoma* is complete containing all the species known at present, other naked gobies hitherto assigned to this genus not belonging to it.

GENERA CLOSELY RELATED TO GOBIOSOMA

Gobiosoma is evidently most closely related to *Garmannia*, a genus in which the posterior part of the body is more or less scaly, rather than to most other genera of completely naked gobies. The two genera agree in their dentition, in the number of dorsal spines being fairly constantly 7, and the general organization and physiognomy of the species being quite similar. There is a gradual transition from the completely scaleless species of *Gobiosoma* to the semi-scaled condition of *Garmannia*, and the line drawn between the two genera is more or less arbitrary as pointed out above (p. 14).

Of the completely scaleless gobies, the two genera most closely related to *Gobiosoma* are probably *Barbulifer* and *Ophiogobius* (see above for references). *Barbulifer* differs in having numerous barbule-like flaps of skin around the mouth and on the underside of the head, and there is a definite tendency to a decreased number of rays in the second dorsal and anal. *Ophiogobius*, as far as may be judged from

descriptions of the only known species, differs from *Gobiosoma* chiefly in having a markedly increased number of rays in the second dorsal, to a lesser extent also in the anal, and in having 8 instead of 7 dorsal spines; possibly other differences will be found on direct comparison of material.

Although scaleless, *Kellogella* Jordan and Seale from Samoa (genotype *K. cardinalis*, see Bull. U. S. Bur. Fish., vol. 23, p. 488, 1905; and vol. 25, p. 409, 1906) is evidently more remotely related than the four genera named in the preceding paragraphs. The type of *Kellogella cardinalis* was examined in the National Museum. Besides having 6 flexible spines in the first dorsal, instead of 7, the number fairly constant in *Gobiosoma* (see p. 14), it also shows an entirely different physiognomy, and a more detailed comparison between *Kellogella* and *Gobiosoma* will most probably reveal other important generic differences. One character which, however, was not studied in detail, may be mentioned here and that is the difference of the distribution of the mucous pores on the head. *Kellogella cardinalis* does not show the rows of papillae on the side of the head like the species of *Gobiosoma*. Instead it has a row of a few rather large pores directly below the eye and a row directly behind the eye. Herre (Gob. Phil. p. 289) also mentions this lack of papillae in his Philippine species of "*Gobiosoma*." This together with the character of 6 dorsal spines make it probable that that species also belongs to *Kellogella*.

The fundamental similarity of *Garmannia* and *Gobiosoma* in nearly all essential generic characters, in combination with the general likeness in the physiognomy of the species of both genera, indicates their close affinity, and shows that the latter genus was derived in a direct line of descent from scaled gobies, such as *Aboma*. Moreover, a consideration of the scaleless gobies from other regions, as reviewed above, shows that this modification evidently appeared independently in widely separated lines of descent. Consequently, to lump all scaleless gobies in one genus, on the basis of this one character, rather tends to hide their true relationship.

Key to the Subgenera and Species of *Gobiosoma*¹

- a. Outer teeth of lower jaw not enlarged. Mouth inferior or sub-inferior, sometimes subterminal. No scales on caudal. Tongue entire. Anterior spine of first dorsal not prolonged. Color pattern longitudinally banded.
subgenus *Elacatinus* (p. 21)

¹ See also account of *G. parri* which is not included in the key.

- b. Mouth distinctly inferior, shark-like. Outer teeth of upper jaw subequal, closely approximated. Teeth in lower jaw coarser, the inner caninoids moderate. Longitudinal white band behind eye broad.

Gobiosoma (Elacatinus) oceanops (p. 22).

- bb. Position of mouth variable, usually inferior or subinferior, sometimes subterminal; lower jaw distinctly included. Enlarged outer teeth of upper jaw more or less spaced, unequal, 1 to 3 caninoids present on side about midway between symphysis and angle of mouth. Teeth of band in lower jaw minute, inner caninoids markedly large. Longitudinal light-colored band behind eye narrow.

Gobiosoma (Elacatinus) horsti (p. 22).

- aa. Outer row of teeth in lower jaw, as well as in upper, more or less enlarged. Mouth terminal or subterminal. Body transversely banded or spotted.

- c. No scales on caudal.

- d. Tongue entire. Barbule in front, at inner margin of upper lip, absent or reduced to a mere pimple. Head moderately depressed, its depth directly behind eye 2.2 in its length or deeper.

- e. Anterior spine of first dorsal notably prolonged in male, extending considerably beyond the following spines. Without a transversely banded color pattern, body faintly spotted. Caudal with cross streaks. Body notably long and slender.

Gobiosoma (Nes) longum (p. 26).

- ee. Anterior spine of first dorsal not prolonged, somewhat shorter than following spines. Typical color pattern of body transversely banded. Caudal without cross streaks. Body comparatively short.....subgenus *Gobiosoma* (p. 27).

- f. Body with 18 to 24 sharply differentiated lighter cross bars. A comparatively short lengthwise band behind eye, red in life, dusky in preserved specimens. Depth medium. Dorsal rays 11 or 12. Anal rays 10. Ventral disk rather short.

Gobiosoma (Gobiosoma) multifasciatum (p. 27).

- ff. Body with 9 lighter cross bars, often irregular or indistinct; no lengthwise band behind eye. Typically stout and deep bodied.

- g. Dorsal rays usually 12, sometimes 11 (13 in 1 specimen from the east coast of Florida, out of 9 counted). Anal rays usually 10, sometimes 11. Ventral rather long, usually 21 to 23% of standard length, varying 20 to 26%; usually 1.3 times in distance from its base to origin of anal, varying 1.2 to 1.5 times. Barbule in front of eye not evident. Head not much wider than high. Typical color: light cross bars not sharply differentiated, frequently oblique or incomplete; broad brown interspaces not uniformly pigmented; median row of small brown spots usually well marked.

Gobiosoma (Gobiosoma) robustum (p. 29).

gg. Dorsal rays usually 13, infrequently 12 or 14. Anal rays usually 11, infrequently 10 or 12. Ventrals notably short, usually 19% of standard length, varying 17 to 20%, usually 1.7 to 1.8 in distance from its base to origin of anal, varying 1.6 to 2.0 times. Barbule in front of eye usually evident, but reduced to a mere pimple. Head directly behind eyes notably wider than high. Light cross bars usually well differentiated, clear-cut, straight; broad brown interspaces usually uniformly pigmented; median row of small brown spots, usually faint or diffuse, frequently absent.

Gobiosoma (Gobiosoma) bosci (p. 32).

dd. Tongue with an abrupt, rather deep and narrow cleft in front. Barbule in front of eye, at posterior edge of upper lip small but well defined. Head notably depressed, its depth directly behind eye 2.4 to 2.5 in its length. Body transversely banded.

subgenus *Aruma* (p. 35).

h. Dorsal and anal rays 13 and 12, respectively. Body moderately stout, depth 20%, least depth of caudal peduncle 12% of standard length. Six white cross bands sharply defined (statement from original description, not now well marked on type, the only specimen studied).....*Gobiosoma (Aruma) histrio* (p. 36).

hh. Dorsal and anal rays 12 and 11, respectively. Body slender, greatest depth 16.5%, least depth of caudal peduncle 10% of standard length. Cross bars yellowish, not sharply differentiated (one specimen studied)..*Gobiosoma (Aruma) occidentale* (p. 37).

cc. Two ctenoid scales present on caudal fin, one near the upper posterior corner of the caudal peduncle and one near the lower. Tongue entire. Anterior spine of first dorsal not prolonged. Body transversely banded.

i. Frenum extending backward from lower lip to chin (the frenum often indistinct in preserved specimens) not bilobed.

subgenus *Dilepidion* (p. 39).

j. Ventral disk not reaching origin of anal, its length 1.2 to 1.5 in distance from its base to origin of anal (relatively longer in young fish). Dark interspaces on body not uniformly pigmented and wider than lighter bars. Anal rays modally 11, varying 10 to 12.

Gobiosoma (Dilepidion) ginsburgi (p. 39).

jj. Ventral disk reaching to origin of anal. Darker interspaces rather uniformly pigmented and subequal in width to lighter bars. Anal rays 10 (in single specimen known).

Gobiosoma (Dilepidion) longipala (p. 42).

ii. Mental frenum bilobed forming two barbule-like flaps.

Gobiosoma (Gerhardinus) nudum (p. 46).

subgenus **Elacatinus**

Elacatinus Jordan, Bull. U. S. Bur. Fish., 22: 542, 1904.

Genotype: Gobiosoma oceanops (Jordan) = *Elacatinus oceanops* Jordan, by original designation and by monotypy.

DEFINITION: No scales on caudal. Outer teeth of lower jaw not enlarged. Mouth distinctly inferior in one species, inferior to subterminal in another. Tongue not cleft. Anterior spine of first dorsal not prolonged. Mental frenum not bilobed. Color pattern longitudinally banded. A tendency shown towards an increased number of anal rays, equalling that of second dorsal, in a considerable percentage of individuals. altho not in the majority.

This is probably the most aberrant subgenus of *Gobiosoma* and should perhaps be treated as a distinct genus. However, no satisfactory structural characters were discovered which would seem adequate for generic separation. *Elacatinus* was originally proposed as a genus differing from *Gobiosoma* chiefly by its decidedly inferior mouth. This character is quite striking in *oceanops*, the genotype, and seems adequate for generic distinction when that species alone is considered; but *horsti* which is evidently most closely related to *oceanops*, forms a transition in that respect between *Elacatinus* and typical *Gobiosoma*. The position of the mouth in *horsti* is quite variable being nearly terminal in some specimens and inferior or almost inferior in others. What seems to be a more fundamental difference distinguishing *Elacatinus* from the other species of *Gobiosoma* is the dentition, none of the outer teeth of the lower jaw being enlarged; but the difference in dentition does not seem sufficient for generic distinction in view of the diversity of that character with the species. The difference in the position of the mouth and the dentition are probably not of more phylogenetic importance than the presence of two scales on the caudal, the cleft tongue, the bilobed frenum, or the filamentous first dorsal spine of the male. The tendency toward an increased number of anal rays, equalling that of the second dorsal, is striking in this subgenus, and is probably an important indicator of phylogenetic divergence; but while this tendency is pronounced, the character is not shown by a majority of individuals, only 14 specimens out of 43 *horsti* having an equal number of rays in the anal and second dorsal; and, moreover, *Dilepidion* is intermediate in this respect between *Gobiosoma* and *Elacatinus*. The longitudinally banded color pattern is unique, but this again is hardly sufficient for generic distinction. A rudiment of this color pattern is shown by the rather short broad band extending backward from the eye in *multifasciatum*.

In consequence of the lack of sufficiently divergent characters, *Elacatinus* is reduced to subgeneric rank. The two species, *horsti* and *oceanops* agree closely in the position of the mouth, the dentition, in showing a tendency to having an increased number of anal rays, and in the peculiar color pattern. They are evidently closely related and are here placed in the same subgenus.

Gobiosoma oceanops

Elacatinus oceanops Jordan, Bull. U. S. Bur. Fish. **22**: 542, pl. 2, f. 3, 1904 (Garden Key, Fla.).

DIAGNOSIS: No scales on caudal. Outer teeth of upper jaw of moderate and nearly uniform size, none conspicuously larger than adjacent teeth in row; closely approximated, not spaced. Teeth in band in lower jaw, rather small but larger than in *horsti*; those in outer row not particularly enlarged, a few moderate caninoids in inner row. Tongue without cleft, with a slight broad emargination. Mental frenum not bilobed. First dorsal spine not filamentous. Mouth distinctly inferior, shark-like. D. 7-13. A. 13. Ventral disk medium, 1.6 in distance from its base to origin of anal, 18% of standard length. Depth moderate, 21%; least depth of caudal peduncle 14%; head 28% of standard length. Head moderately depressed, its depth directly behind eye 2 in its length, 14% of standard length. Anterior nostril in a very short tubule; posterior nostril with a raised edge. Barbule in front of eye reduced to a mere pimple. A broad whitish band from eye to caudal, a little over the median line, continued to snout and becoming narrower in front of eye; back above white band dark brown, the color of the back continued as a somewhat curved, narrow band on caudal fin; a similar dark brown and wider band below the white band, the inferior brown band continued on lower half of caudal fin, its lower boundary merging imperceptibly with the lighter color of the underside of the fish.

SIZE: The largest specimen recorded in the original description is 2 inches (50 mm.).

GEOGRAPHICAL DISTRIBUTION: This species is known from 5 specimens obtained at Garden Key, Fla. The above account is based on one of the paratypes, a male, 33 mm. in total length. There appears to be no other records.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: This species is most closely related to *horsti*, agreeing with it in the color pattern, the number of fin rays and the dentition of the lower jaw. It differs from *horsti* in its more slender body, in having the outer teeth of the upper jaw subequal and closely approximated, and in the longitudinal white band being broader. The position of the mouth which is distinctly inferior and shark-like in *oceanops* varies in *horsti* from inferior to subterminal, but it is never placed as far back as in the present species.

Gobiosoma horsti

Gobiosoma bosci Hilgendorf, Sitzber. Naturf. Freunde Berlin, **1889**: 51 (Haiti.

This record may possibly refer to *horsti* which is the only naked goby now known from Haiti. It is very doubtful whether it is based on specimens of the true *bosci*).

Gobiosoma horsti Metzlaar, Bijdr. Dierk. Amsterdam, **22**: 139, fig., 1922 (Curaçao).

Gobiosoma horsti Beebe and Tee-Van, *Zoologica* 10: 224, fig., 1928 (Haiti).

Gobiosoma chancei Beebe and Hollister, *Zoologica* 12: 87, f. 17, 1933. (St. George Bay, Granada, B. W. I.).

DIAGNOSIS: Entirely scaleless, no scales on caudal fin as well as on body and caudal peduncle. Villiform teeth in a band in each jaw, broad at the symphysis, tapering off laterally; outer row of upper jaw enlarged, the enlarged teeth rather widely spaced, some caninoids (usually 1 to 3) in outer row, on side, conspicuously larger than those at symphysis; lower jaw with similar caninoids on the side, somewhat larger than those of upper jaw, occupying a position posterior to band of villiform teeth; outer row of lower jaw not enlarged. Tongue entire. Mental frenum not bilobed. Anterior spine of first dorsal not filamentous. Position of mouth variable, nearly terminal in some specimens to inferior in others; lower jaw distinctly included. First dorsal nearly always with 7 flexible spines (42 specimens), infrequently 8 (in 1). Second dorsal modally with 12 rays, commonly also 13, infrequently 11. Anal rays 11 or 12, the frequency of occurrence of these two counts being nearly the same; the anal with one ray less than the dorsal in most individuals, quite often the same number in both fins (in 14 specimens out of 43 counted). Ventral medium 19 to 23% of standard length, 1.2 to 1.4 in distance from its origin to origin of anal (measured to tip of median rays which are somewhat filamentous). Body of medium depth; greatest depth 20 to 25%, least depth of caudal peduncle 12 to 15% of standard length. Depth of head directly behind eyes usually about equal to its width at same point, sometimes somewhat deeper than wide; the depth of head 1.4 to 1.6 in its length, 16.5 to 19% of standard length. Length of head 25 to 28%. Maxillary attaining to a vertical thru hind margin of eye or a little beyond, its length 11 to 13% of standard length. (The extension of the posterior end of the maxillary and the proportional measurements given above refer to 10 specimens, 36 to 59 mm. in total length.) Anterior nostril in a very short tubule, posterior nostril with its edge somewhat raised; usually no indication of a barbule in front of eye, sometimes a pimple present in position occupied by barbule in related species. No cross bars. A characteristic longitudinal whitish band, usually with a dark streak along its middle, under the dorsal profile, from eye to base of caudal, sometimes more or less incomplete. In life the white band is either blue (according to Beebe and Tee-Van) or yellow (according to Beebe and Hollister). Upper half brownish, lower half lighter; boundary between contrasting upper and lower colors usually sharply defined, sometimes colors above and below imperceptibly merging; a median row of small brown spots sometimes present at boundary of contrasting colors; a dark rather diffuse blotch at base of caudal, frequently continued more or less on caudal fin as on irregular dark band.

COLOR CHANGE: The following changes in color pattern take place with age (based on preserved specimens). In very small specimens, those of about 15 mm. total length, there is a broad, dark, longitudinal median band from the

eye to the caudal fin, extending more or less on the latter as an elongate dark spot; and a fine dark longitudinal streak under the dorsal profile from the eye to the base of the caudal. As the fish increase in size, the upper half above the median band gradually becomes pigmented, except along the upper and lower edges of the fine dark streak under the dorsal profile, as described above, where the pigment is quite sparse, presenting the gross appearance of two whitish streaks, above and below the fine dark streak. The central dark streak gradually disappears or becomes faint, giving the impression to the naked eye of a solid white band, but the darker core of the white band is plainly evident in most specimens on close examination.

CORRELATION BETWEEN THE NUMBER OF RAYS IN THE VERTICAL FINS: The following table shows the correlation between the dorsal and anal rays. Note the pronounced tendency shown by this species of having the same number of rays in both vertical fins. Compare with *bosci*, *robustum*, and *ginsburgi* and note that *Elacatinus* shows the opposite extreme to *Gobiosoma* in this respect, while *Dilepidion* is intermediate.

Anal rays	Dorsal rays		
	11	12	13
11	2	15	3
12		12	11

SIZE: The largest specimen examined, a male, measured 59 mm. in total length, 46 mm. without the caudal fin. The largest female is 55 mm.

GEOGRAPHICAL DISTRIBUTION AND MATERIAL STUDIED: As shown by the above references, this species is now known from three West Indian Islands, namely, Curaçao, Haiti, and Granada. The above account is based on 44 specimens collected by Beebe and Tee-Van at Port-au-Prince, Haiti.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The present species is evidently quite closely related to *oceanops*. The two have essentially the same dentition and the longitudinally banded color pattern; and the mouth in *horsti* is often rather inferior, although never placed as far back of the tip of the snout as in *oceanops*. It may be distinguished from the latter by the white band not being as wide, by the outer teeth of upper jaw being unequal, as well as by the position of the mouth. As compared with all other known species of *Gobiosoma*, *horsti* is easily recognized by its distinctive color.

SEX RATIO: The 44 specimens studied were sexed by the difference in structure of the anal papilla as described below (p. 48). In 4 specimens, 15 to 28 mm., the anal papilla was such that the sex could not be determined with certainty. The rest consisted of 16 females 28 to 55 mm., and 24 males 34 to 59 mm. in total length. The males thus outnumber the females in this species also, but

the difference in their numbers is not as great as in the other species which were sexed (compare with p. 48).

SYNONYMY: A new name, *G. chancei*, based on a single specimen of what appears to be the present species was lately introduced by Beebe and Hollister as indicated in the synonymy. According to the authors *chancei* differs from *horsti* in lacking scales on the caudal peduncle, in having the origins of the dorsal fins more posterior in position and in the light colored band being shorter, not extending to the caudal, and yellow instead of blue. These differences evidently do not hold. Assuming that the specimens from Haiti, which were determined by Beebe and Tee-Van as *horsti* and on which the above account is based, to have been correctly identified—and there is nothing in the original description of *horsti* which would indicate otherwise—the account by Beebe and Hollister may now be compared with *horsti*. The Haitian specimens do not have any scales, neither on the caudal peduncle nor on the caudal fin. Consequently, *chancei* can not be separated from *horsti* on that basis. In the original description, also, Metzlaar states, "no scales discernible anywhere." The other supposed difference, the position of the dorsal fins, is apparent only when a specimen is compared with the outline figure published by Metzlaar which is obviously erroneous in respect to the position of the dorsals. As a matter of fact, the origin of the first dorsal is on a point behind a vertical through the base of the pectoral and that of the second dorsal more or less in front of the anus, in all the species, these characters being generic. This leaves only the shorter white band of the type specimen of *chancei* to be considered. This difference is no doubt due to individual variability, the 44 specimens examined showing a considerable amount of variation in the extent and intensity of development of the white band. The yellow color of the band in life, instead of being blue, is not impressive, considering the changeability of shades of color to which tropical fishes are subject. One important difference not especially pointed out by the authors, is found in the anal count which is stated to be 10 in the type of *chancei*, while in 43 specimens from Haiti the rays are 11 or 12; but this difference is not dependable when taken by itself. The color pattern and the shape of the type of *chancei* is quite typical of *horsti* as shown by a comparison of the specimens from Haiti with the figure of *chancei*.

As far as may be judged by the published account of *horsti*, the specimens from Haiti on which the above account is based are examples of that species. Should a comparison with the types of *horsti* prove otherwise, the above account as well as that of Beebe and Tee-Van, both refer to *chancei*. However, in view of the distinctive character of the species and its apparent abundance, it is not advisable to use two names for what appears to be the same species, unless convincing evidence for such action is adduced.

Nes, new subgenus

GENOTYPE: *Gobiosoma longum* Nichols.

DEFINITION: This subgenus differs from typical *Gobiosoma* in that the first dorsal spine of the male is filamentous being prolonged much beyond the end of

the following spines. In the related genus *Garmannia* this character is a constant feature of the species, and it is evidently of as much importance in indicating phylogenetic lines of development, among the species under consideration, as the cleft tongue, the bilobed frenum or even the presence of two scales on the caudal. The other subgenera of *Gobiosoma* do not show this character. The genotype further differs from typical *Gobiosoma* in the color pattern being spotted, faintly, instead of being cross-barred.

Gobiosoma longum

Gobiosoma longum Nichols, Bull. Amer. Mus. Nat. Hist. **33**: 143, 1914 (Florida Keys, near Key West).

Gobiosoma longum Metzlaar, Rap. Kolonie Curaçao, p. 139, 1919 (Aruba Island).

Gobiasoma [sic] *longum* Grant, Copeia, **163**: 45, 1927 (Another record of the type specimen, taken near Key West, thrown up by a snapper, "*Neomaenus ambiguus*," after capture).

Gobiosoma longum Beebe and Tee-Van, Zoologica, **13**: 120, 1932 (Bermuda).

DIAGNOSIS (based on two specimens): No scales on caudal. Outer row of teeth moderately enlarged in both jaws. Tongue entire. Mental frenum not bilobed. First dorsal with 7 flexible spines, the first spine filamentous, extending beyond the following spines, reaching origin of second dorsal when extended along back. Second dorsal with 13 or 14 rays. Anal with 12 or 13 rays. Ventral disk markedly short, 12.7 to 14.9% of standard length, 1.8 to 2.2 times in distance from its base to origin of anal. Body conspicuously long and slender, greatest depth 11.9 to 14.9%; least depth of caudal peduncle 6.6 to 7.7% of standard length. Head moderately depressed, its depth directly behind eye 1.9 to 2.2 in its length, 9.9 to 11.4% of standard length. Anterior nostril in a short tubule; posterior nostril with a somewhat raised rim. Barbule in front of eye not evident. Nearly colorless, upper part with faint spots, more marked anteriorly and on top of head; ventral disk dusky; caudal rather faintly cross-barred. Mr. John Tee-Van has kindly supplied the following color notes of the specimen taken in Bermuda by Beebe and Tee-Van. "Color in life: grayish white with small irregular dull orange spots on the body and on the fins, those on the caudal fin in the form of somewhat irregular vertical narrow bands."

Other pertinent characters as shown by the two specimens are as follows. Caudal peduncle markedly long, 15.7 to 16.9% of standard length, when measured on midline from a point below end of dorsal to base of caudal. Maxillary reaching a vertical thru, or slightly past, posterior margin of eye. Head 21.3 to 21.5%, eye 4.9 to 5.1%, maxillary 9.8 to 10% of standard length. (The type specimen is partly shriveled, and the above measurements may not be entirely accurate.)

SIZE: This is the largest known species of *Gobiosoma*. The specimen from Bermuda is 105 mm. long, 84 mm. in standard length.

GEOGRAPHICAL DISTRIBUTION AND MATERIAL STUDIED: The species is now known from but three specimens, from the following three localities, namely, near Key West, the type locality, Bermuda, and Aruba Island. The above account is based on the two specimens from the first named localities.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: This species is unique among its congeners by its strikingly long and slender body and caudal peduncle, and the comparatively long, filamentous first dorsal spine. Its large size will readily distinguish adult specimens. In its short ventral disk and the comparatively numerous fin rays it stands nearest to *bosci*, the two species evidently intergrading in those characters. The color pattern differs from the members of the typical subgenus in that the body is faintly spotted instead of being cross-barred; while the caudal fin is cross-barred instead of being uniformly pigmented.

subgenus **Gobiosoma**

Gobiosoma Girard, Pr. Ac. Nat. Sc. Philadelphia, p. 169, 1858.

GENOTYPE: *Gobiosoma bosci* Lacepede = *Gobiosoma molestum* Girard by subsequent designation (and by monotypy, all the specific names cited in original description being synonyms).

Gobiosoma Bleeker, Arch. Neerland, Sc. Nat. **9**: 310, 1874. (Esq. Gob. p. 22; *Gobiosoma molestum* Girard designated as genotype.)

Gobiosoma Jordan and Gilbert, Bull. U. S. Nat. Mus. **16**: 638, 1882. (*Gobius alepidotus* Bloch and Schneider designated as genotype.)

DEFINITION: No scales on caudal. Outer row of teeth enlarged in both jaws. Tongue entire. Mental frenum not bilobed. First dorsal ray not filamentous. Mouth terminal or nearly terminal. Typical color pattern of body transversely cross-barred.

Gobiosoma multifasciatum

Gobius lineatus Poey (a homonym of *Gobius lineatus* Jenyns, 1842), Memorias Hist. Nat. Cuba, **2**: 424, 1861 (Cuba).

Gobiosoma multifasciatum Steindachner, Sitzber. k. k. Ak. Wiss. Wien **74** (abt. 1): 231 and 238 (Ichthyol. Beit. **5**: 183 and 190) 1876 (St. Thomas; Barbados and Bartholomew, Lesser Antilles).

Gobiosoma multifasciatum Eigenmann and Eigenmann, Pr. California Ac. Sc. (2) **1**: 73, 1888 (St. Thomas).

Gobiosoma multifasciatum Jordan and Evermann, Bull. U. S. Nat. Mus. **47** (3): 2260, 1898.

Gobiosoma viridistriatum Silvester, Pap. Dep. Mar. Biol. Carnegie Inst. Washington **12**: 24, pl. 3, fig. 3, 1918 (Puerto Rico).

Gobiosoma multifasciatum Fowler, Pr. Ac. Nat. Sc. Philadelphia **80**: 466, 1928 (Puerto Rico).

Gobiosoma viridistriatum Fowler, l. c., **83**: 401, 1931 (compared with *G. macrodon*)

DIAGNOSIS (based on small specimens only): No scales on caudal. Outer row of teeth enlarged in lower as well as in upper jaw. Tongue not cleft. Mental frenum not bilobed. (First dorsal spine of a male 22 mm. long, not filamentous; but Silvester's figure shows the first spine slightly filamentous in a specimen of about the same size.) First dorsal with 7 flexible spines (5 specimens). Second dorsal rays 11 (in 2 specimens) or 12 (in 3). Anal rays 10 (in 5). Ventral disk rather short 18.3% of standard length, 1.6 times in distance from its origin to origin of anal. Depth medium, 21%; depth of caudal peduncle 11.7% of standard length. Head moderately depressed, its depth directly behind eye 1.9 in its length, 18% of standard length. Anterior nostril with its rim slightly raised. Barbule in front of eye not evident. Body with 19 to 24, sharply defined, narrow, light cross bars, more crowded posteriorly; the bars separated by uniformly pigmented wider interspaces; a broad, dark band extending lengthwise behind eye. According to Poey, Steindachner and Silvester the dark interspaces are green in life and the band behind the eye is red.

SIZE: The length given by Poey, 43 mm., appears to be the largest on record.

GEOGRAPHICAL DISTRIBUTION AND MATERIAL STUDIED: The present species has been reported from Cuba; Puerto Rico; St. Thomas, Virgin Ids.; Bartholomew and Barbadoes, Lesser Antilles. The specimens recorded under this name from Curaçao by Metzlaar and apparently repeated by Koumans probably belong to *Garmannia macrodon* (see p. 53 for references and p. 55 for discussion). The above account is based on 5 small specimens, the measurements given being based on a single individual as follows: St. Thomas, Virgin Ids., 1 specimen, 22 mm. total length, 18 mm. standard length (M. C. Z. 13317, being the specimen recorded by Eigenmann and Eigenmann). The data for the other specimens are: Cabanos Bay, Cuba; June 8 to 9, 1914; Bartsch and Henderson; 4 specimens, 11 to 12 mm. total length (U. S. N. M. 82523). Judging by the records in the literature, this species appears to be not uncommon in the West Indies.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The number of fin rays in the present species is nearly like in *robustum*. It is more slender than either *robustum* or *bosci* but not quite as slender as *longum*. It is readily recognized by its distinctive color pattern; in the presence of many, sharply defined, narrow light cross bars it is unlike any other species of its genus.

SYNONYMY: Silvester states that his *viridistriatum* is different from Steindachner's *multifasciatum*, but he does not point out the differences. The original descriptions of both authors are so remarkably alike, that the later name is placed in synonymy here. More proof than a mere statement is needed to convince one that the material described by the two authors represent distinct species. The only significant difference in the two descriptions is that Steindachner states the number of spines in the first dorsal to be six. However, considering that all the species of *Gobiosoma* have seven dorsal spines, with rare

individual exceptions, this record of six is most likely an error. It should also be noted that Fowler in 1928 records *G. multifasciatum* from Puerto Rico based on the material collected by Silvester and again, in 1931, the same author evidently recognizes *G. viridistriatum* as distinct. This would make it seem probable that after all two species are involved. Nevertheless, if there are in fact two related species having a similar color pattern, their differences have not as yet been pointed out, and the necessary material is not available for study to decide the question.

Gobiosoma robustum

Gobiosoma alepidotum Jordan and Gilbert (not Bloch and Schneider), Pr. U. S. Nat. Mus. **5**: 297, 1882 (Pensacola, Fla.).

Gobiosoma bosci Jordan and Gilbert (not Lacepede, probably based on same material as preceding record), Bull. U. S. Nat. Mus. **16**: 948, 1882.

Gobiosoma molestum Eigenmann and Eigenmann (not Girard), Pr. California Ac. Sc. (2) **1**: 72, 1888 (specimen from Bahia reexamined).

Gobiosoma molestum Evermann and Kendall (not Girard), Bull. U. S. Fish. Comm. **12**: 118, 1894 (Corpus Christi, Texas).

Gobiosoma bosci Evermann and Bean (not Lacepede), Rep. U. S. Comm. Fish., **1896**: 247, 1898 (Indian River at Cocoa, Fla.).

Gobiosoma robustum Ginsburg, Pr. U. S. Nat. Mus. **82** (20): 15, 1933.

DIAGNOSIS: No scales on caudal. Outer row of teeth enlarged in lower as well as in upper jaw. Tongue entire. Mental frenum not bilobed. First dorsal nearly always with 7 flexible spines (in 20 specimens) infrequently 6 (in 1) or 8 (in 1), the first spine not prolonged. Rays of second dorsal normally 12 (in 25), often 11 (in 10), infrequently 13 (in 1 specimen from Cocoa, on the east coast of Florida out of 9 studied). Anal rays mostly 10 (in 31), sometimes 11 (in 5). Ventral medium, not reaching origin of anal, modally 1.3 in distance from its base to origin of anal, varying 1.2 to 1.5; 21 to 23% of standard length in most specimens, varying 20 to 26%. Typical specimens notably short and stocky, greatest depth usually 22 to 25% of standard length, varying 22 to 27%. Least depth of caudal peduncle usually 14 to 15%, varying 13 to 16%. (For the number of specimens studied in detail and the frequency distributions of these characters see Tables 1-6.) Depth of head directly behind eyes somewhat but not much less than its width, 1.7 to 1.9 in its length, 16 to 18% of standard length (range of 10 specimens 29 to 45 mm. in standard length). Anterior nostril ending in a short tubule, posterior nostril with its rim slightly raised. Barbule in front of eye not evident. Body typically cross-barred with about 9 broader darker bands alternated with narrower lighter bars; the alternating bars and bands not sharply delimited; the dark bands not uniformly pigmented, mottled with lighter and darker shades; lighter bars usually not altogether straight, more or less sinuous or oblique, often incomplete; a median lengthwise row of small brown spots typically present, usually one spot on a band, sometimes

two. Sometimes nearly uniformly pigmented, the typical color pattern not being evident, either light all over or quite dark to nearly black. Fins nearly uniformly dusky, ventral and first dorsal darkest, the latter often blotched with black.

CORRELATION OF NUMBER OF RAYS IN VERTICAL FINS: The following table shows that the anal has two rays less than the dorsal in the majority of specimens. This is true also of *bosci* and is evidently the typical condition in the subgenus *Gobiosoma* (compare with *bosci*, *ginsburgi*, and *horsti*).

Anal rays	Dorsal rays		
	11	12	13
10	9	22	
11	1	3	1

SIZE: The largest specimen studied is a male 55.5 mm. in total length, 45 mm. without the caudal (see also p. 51 for Fowler's record of specimens from Laguna Madre, Tex.).

GEOGRAPHICAL DISTRIBUTION: Specimens have been studied from Indian River at Cocoa, Cape Sable, Apalachicola, and Pensacola, Florida; Cat Island, Mississippi; Grand Isle, Louisiana; Corpus Christi, Texas; Bahia, Brazil. This represents the known and authenticated range of the species at the time this is written. This is a common species on the Gulf coast. Judging by the material examined it is perhaps slightly more common than *bosci*, but the collections are not extensive enough to definitely judge the relative abundance of the two.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The present species is notable for its short chunky body. In this respect it resembles closely *G. bosci* which occurs with it through a large part of its range. While the two species are evidently very closely related and have been confused by nearly all authors, *robustum* differs from *bosci* in having a longer ventral disk and in having the dorsal and anal rays modally at 12 and 10, respectively, instead of 13 and 11 (see Tables 1, 2, 3, and 6). The two species intergrade to some extent in all the three chief differentiating characters, but such intergradation is not of a high degree. Most specimens may be distinguished at a glance by the difference in color. In *robustum* the lighter bars usually are not as straight and clear cut as in *bosci*; while the broader darker bands are not uniformly pigmented but are shaded with lighter and darker blotches; but the color differences are often not reliably distinctive. Specimens of either species are frequently encountered which are uniformly pigmented, sometimes being nearly black all over. However, when all characters are taken in consideration there is seldom trouble in placing even individual fish.

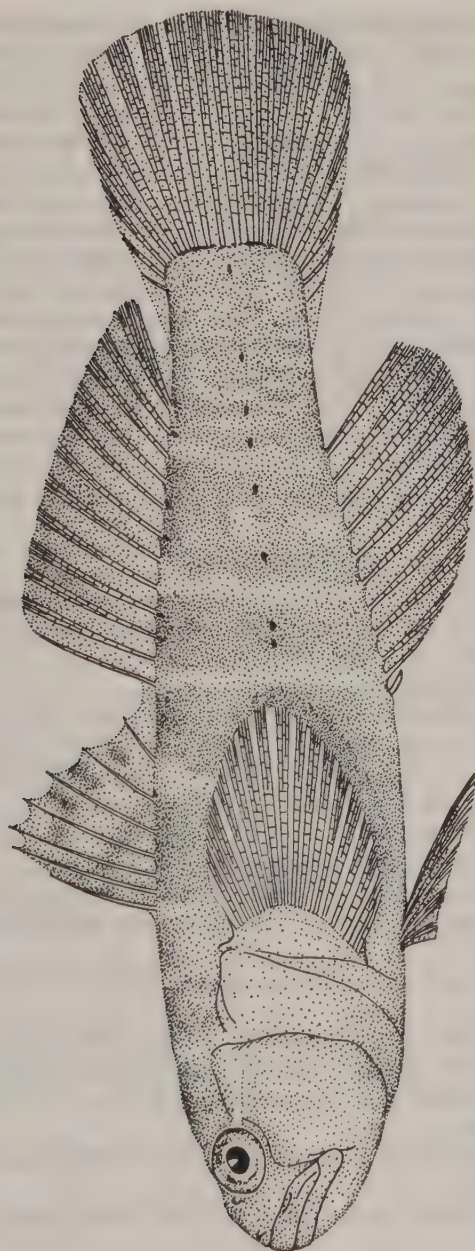


Figure 1. *Gobiosoma robustum*, from the type specimen, a male, 55.5 mm. in total length. Laguna Madre, near Corpus Christi Pass, Texas.

NOMENCLATURE: Although this species is common, it was named only recently. As stated, the naked gobies of the Gulf Coast have been generally treated as consisting of one species, with the exception of Kendall and Evermann (see discussion, pp. 2 to 7). The present comparative study of the species comprising the genus *Gobiosoma* showed unmistakably that two common species which may be quite readily differentiated occur together on the Gulf Coast as discussed above at some length. Most previous authors may be divided into two categories, 1) those who were of the opinion that all naked gobies of the east coast consist of one species, to which the oldest name, *bosci*, was applied, and 2) those who assumed that there are two species, *bosci* on the Atlantic Coast and *molestum* on the Gulf Coast. The present study showed definitely that two common species occur on the northern coast of the Gulf of Mexico. Also, an examination of the type of *molestum* showed that it was based on a specimen of *bosci* (see p. 35). This of course left the other common species without a valid name, and a preliminary description of the species was published as indicated in the synonymy. The specific name *molestum* as heretofore used by most authors was in fact applied to a composite of two quite distinct species.

Gobiosoma bosci

Gobius bosc Lacepede, Hist. Nat. Poisson **2**: 555, fig., 1800 (Charleston, S. C., from a manuscript by Bosc.; as restricted by Hildebrand and Schroeder.)

Gobius alepidotus Bloch and Schneider, Syst. Ichthyol. p. 547, 1801 (Apparently based on Lacepede's account.)

Gobius viridipallidus Mitchil, Trans. Lit. Philos. Soc. New York, **1**: 379, pl. 1, fig. 8, 1815 (New York; as restricted by Cuvier and Valenciennes).

Gobius boscii Cuvier and Valenciennes, Hist. Nat. Poiss. **12**: 96 [quarto ed. p. 72], 1837 (the preceding three names first synonymized).

Gobiosoma molestum Girard, Pr. Ac. Nat. Sc. Philadelphia, p. 169, 1858 (Texas; type reexamined; based on a specimen of the present species.)

Gobiosoma molestum Girard, U. S. and Mex. Bound. Survey, pt. 2, Ichthyology, p. 27, pl. 12, fig. 14, 1859 (Texas, based on same specimen as preceding record).

Gobiosoma molestum Gunther, Cat. Fish. Brit. Mus. **3**: 556, 1861 (Texas, after Girard).

Gobiosoma alepidota Uhler and Lugger, Rep. Comm. Fish. Maryland, p. 100, Jan. 1, 1876 and p. 84, January, 1876 (Worcester County, Maryland.)

Gobiosoma molestum Jordan and Gilbert, Bull. U. S. Nat. Mus. **16**: 638, 1882 (Texas, after Girard).

Gobiosoma bosci Bean, Bull. U. S. Fish. Comm. **7**: 136, 1889 (Somers Point and Ocean City, N. J.).

Gobiosoma bosci Bean, Rep. Comm. Fish. New York. **19**: 249, 1890 (Long Island, New York).

- Gobiosoma bosci* Bean, Pr. U. S. Nat. Mus. **14**: 86, 1892 (Cape Charles, Va.).
Gobiosoma bosci Evermann and Kendall, Bull. U. S. Fish. Comm. **12**: 118, 1894 (Galveston and Corpus Christi, Tex.).
Gobiosoma bosci Smith and Bean (in part), Bull. U. S. Fish. Comm. **18**: 187, 1898 (Potomac River at Gunston Wharf, Va.).
Gobiosoma bosci Evermann, Rep. U. S. Comm. Fish. **1898**: 310, 1899 (Baldwin Lodge, Miss.).
Gobiosoma bosci Bean, 52 Ann. Rep. New York State Mus., 1898, vol. 1, p. r109, 1900 (Long Island, many localities, some of the specimens reexamined).
Gobiosoma bosci Jordan and Dickerson, Pr. U. S. Nat. Mus. **34**: 21, 1908 (Tampico, Mexico).
Gobiosoma bosci Hildebrand and Schroeder, Bull. U. S. Bur. Fish., **43** (1): 323, fig. 194, 1928 (Chesapeake Bay, many localities).

DIAGNOSIS: No scales on caudal. Outer row of teeth enlarged in lower as well as in upper jaw. Tongue entire. Mental frenum not bilobed. Mouth low but terminal, both jaws equal in front. First dorsal spine not filamentous. Number of spines in first dorsal nearly always 7 (in 22), sometimes 8 (in 2). Rays in second dorsal nearly always 13, infrequently 12 or 14, anal rays nearly always 11, infrequently 10 or 12. Ventral conspicuously short, its length usually 1.7 or 1.8 in the distance from its origin to origin of anal, varying 1.6 to 2.0; modally 19% of standard length, varying 17 to 20%. Body rather short and stocky, the greatest depth modally 23%. Least depth of caudal peduncle usually 13 to 15% of body length, varying 12 to 16% (for the number of specimens studied in detail and the frequency distributions see Tables 1-6). Depth of head 2.0 to 2.2 times in its length, 14 to 16% of standard length (range of 15 specimens measured, 30 to 43 mm. in standard length). Anterior nostril in a very short tubule, usually shorter than in *robustum*; posterior nostril usually with a somewhat raised edge; barbule in front of eye usually perceptible, but reduced to a mere pimple. Body with about 9 whitish cross bars, typically straight and clear-cut, narrow streaks; the broad brown interspaces uniformly pigmented; the median row of small brown spots usually not prominent, often quite faint and sometimes absent, especially in larger examples. Sometimes nearly uniformly pigmented, either light colored or very dark all over to nearly black.

CORRELATION OF NUMBER OF RAYS IN VERTICAL FINS: The following table shows the typical condition in the subgenus *Gobiosoma*, the anal having 2 rays less than the dorsal in the majority of specimens, often 1 or 3 less. This typical correlation is even more pronounced than in *robustum*.

Anal rays	Dorsal rays		
	12	13	14
10		3	
11	4	29	4
12		5	1

SIZE: The largest specimen examined, a male, from Savannah Harbor, Ga., is 64 mm. in total length, 53 mm. to base of caudal. In more than 300 other specimens examined the length was 60 mm. or less. The largest female examined is but 47 mm. in total length, the females evidently not attaining to the maximum size of the males, this being probably true of all the species of this genus (see p. 49 for further discussion of the relative maximum size of the sexes).

GEOGRAPHICAL DISTRIBUTION AND MATERIAL STUDIED: Over 300 specimens in all were examined from the following localities: Fire Island, Swan River, Hoyles Point, and Blue Point Cove, Long Island; Somers Point, New Jersey; Chesapeake Bay, many localities in Maryland and Virginia; Gallants Point, Beaufort, North Carolina; Savannah Harbor Georgia; Baldwin Lodge, Grand Plains Bayou, and Cat Island, Mississippi; Grand Isle, and Morgan City, Louisiana; Matagorda Bay and various localities in the vicinity of Corpus Christi, Texas; Tampico, Mexico. The authenticated range of *bosci* is therefore Long Island, New York to Tampico, Mexico. Records of this species north of Long Island appear doubtful and should be verified. The three lots of *Gobiosoma* in the collection of the U. S. National Museum, which were taken north of Long Island, are all *ginsburgi* (see p. 40). Likewise, the record of "*bosci*" from *Haiti* by Hilgendorf (see p. 22), appears quite doubtful, according to the present study. This species is abundant in Chesapeake Bay and appears to be quite common on the coasts of New Jersey and Long Island. It was found to be common on the coasts of Mississippi, Louisiana, and Texas.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The present species is most closely related to *robustum*, differing from the latter in the more numerous fin rays, the shorter ventral disk, and the color pattern, as pointed out above (p. 30). The majority of specimens may be distinguished from *robustum* with ease by the typical color pattern; the straight, narrow, clear-cut, whitish cross-streaks, and the uniformly pigmented, wide, darker interspaces. The two species occur together and are common through the southern part of the range of *bosci*. While the present extensive comparative study has definitely proven their distinctness, they are so similar in general appearance that they have been confused by nearly all previous writers. On the Atlantic Coast, north of Florida to Long Island, the range of *bosci* overlaps that of *ginsburgi*; and, likewise, both are common there, are similar in appearance, and have been generally confused. However, *bosci* may be readily distinguished by the absence of two scales on the caudal, while such scales are constantly present in *ginsburgi*.

NOMENCLATURE AND SYNONYMY: The application of the name *bosci* to the present species may be open to question. The type locality of *bosci* is South Carolina; but two distinct species, one having two scales on the caudal and one lacking such scales, are now definitely shown to occur on the coast of that state. The color and the given number of dorsal rays, fourteen in the original account, apply more to the present species; but the description is inadequate to be deci-

sive. The restriction of the name *bosci* to the present species was established by Hildebrand and Schroeder (1928) who first correctly distinguished the same two species while working with specimens from Chesapeake Bay. In the absence of any data showing the contrary, the restriction proposed by these authors is here adopted. Also, in view of the fact that the present species is more common, at least in collections obtained by the usual methods, and occurs in more accessible, shallow water, than the one having the two scales, the probabilities are in favor of the assumption that *bosci* was based on specimens of the present species. Of course, should the original material be found to exist and to be composed wholly of the species having two scales on the caudal, then the name *bosci* will have to be applied to that species designated as *ginsburgi* in this paper; while the present species will take the name of *molestum*. On the other hand, should the original material be found to include both species, the restriction as made by Hildebrand and Schroeder will have to stand.

The type of *molestum* which is still in existence in the National Museum has been reexamined. It is in bad condition and consequently not all the pertinent specific characters can be studied. The dorsal has at least 13 rays, possibly 14. The anal rays are less easily determinable but they evidently number 11. These numbers show that the specimen is an example of the present species. Girard's statement, "ventrals quite small . . ." would also indicate that he had an example of *bosci* before him. The markedly short, almost circular, ventral disk of this species is likely to impress the eye particularly, while the disk in the preceding species is of the usual shape and form and is not apt to draw special attention. Furthermore, the figure also shows the short ventral typical of *bosci*. The type specimen has only a small stump left of the ventral disk and its original length is not evident now.

In reducing the name *molestum* to the synonymy of *bosci*, it is interesting to point out that not only is this necessary for the reasons stated, but it also happens to be a desirable course to follow. That name as generally used was really applied to a composite of two species. It, therefore, seems to be a fortunate coincidence that the sole specimen on which *molestum* was based, happens to be an example of a previously established species. The necessary suppression of a name thus used for a composite of two distinct species, will clear away some of the resulting confusion.

SPAWNING: A lot of fish collected in the lower end of Rappahannock River, Va., July 23 to August 1, 1921, is entirely mature and about to spawn. For data regarding the sex ratio see below (p. 48).

subgenus **Aruma**

Aruma Ginsburg, Pr. U. S. Nat. Mus. **82** (20): 16, 1933.

GENOTYPE: *Gobiosoma occidentale* Ginsburg, by original designation.

DEFINITION: This subgenus differs from the typical subgenus as well as the other subgenera, chiefly in having a deeply cleft tongue. The two species

comprising this subgenus also have a small but plainly evident barbule in front of the eye, while in the other subgenera the barbule is either absent or reduced; the barbule in *Gerhardinus* approaching in size that of *Aruma*. Head notably depressed. No scales on caudal. Outer row of teeth enlarged in both jaws. Mental frenum not bilobed. Mouth terminal. *Aruma* contains two known species, *occidentale* and *histrio*.

Gobiosoma histrio

Gobiosoma histrio Jordan, Pr. U. S. Nat. Mus. **7**: 260, 1884 (Guaymas, Mexico).

Gobiosoma histrio Jordan and Eigenmann, Pr. U. S. Nat. Mus. **9**: 508, 1886.

Gobiosoma histrio Evermann and Jenkins, Pr. U. S. Nat. Mus. **14**: 162, 1892 (Guaymas, Mexico).

Gobiosoma histrio Jordan and Evermann, Bull. U. S. Nat. Mus. **47** (3): 2258, 1898.

Gobiosoma histrio Pellegrin, Bull. Mus. Hist. Nat. Paris **7**: 162, 1901 (Gulf of California).

Gobiosoma histrio Osburn and Nichols, Bull. Amer. Mus. Nat. Hist. **35**: 175, 1916 (San Francisquito Bay, Gulf of California).

Gobiosoma histrio Wales, Copeia **1932**: 168 (Bahia de Concepcion, Lower California).

DIAGNOSIS: No scales on caudal. Outer row of teeth in both jaws enlarged. Tongue deeply cleft. Mental frenum not bilobed. Mouth terminal. (Anterior dorsal spine broken in only specimen examined). D 7-13. A 12. Body moderately elongate, 20%; least depth of caudal peduncle 12%; head 30%; maxillary 12.6%; snout 7.7%; eye 5.9% of standard length. Head markedly depressed, its depth directly behind eye 2.4 in its length, 12.3% of standard length. Small barbule in front of eye, at inner edge of upper lip, apparently present (skin of specimen studied partly destroyed and consequently presence of barbule not altogether certain; for same reason nostrils can not be described). Color now faded, but traces of light bars still perceptible when kept under water. In the original account the color is described as "blackish, with six white cross-bands sharply defined."

SIZE: The type which is also the largest known specimen is 48 mm. long, 40.5 mm. in standard length.

GEOGRAPHICAL DISTRIBUTION AND MATERIAL STUDIED: According to the records in the literature, *histrio* is now known from 3 localities in the Gulf of California, namely, Guaymas, the type locality, Bahia de Concepcion, and San Francisquito Bay; and one record by Pellegrin from that body of water without any more definite locality. The records are, of course, as given by the various authors, not having examined the material on which these records are based. The above account is based on the type specimen only.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The present species may be

distinguished from all other known species of *Gobiosoma*, except *occidentale*, by its deeply cleft tongue. In this character it agrees with and is closely related to *occidentale* differing from the latter in having one more ray in the second dorsal and anal, a deeper body, and perhaps also in color pattern.

Gobiosoma occidentale

Gobiosoma occidentale Ginsburg, Pr. U. S. Nat. Mus. **82** (20): 16, 1933 (La Paz, Mexico).

DIAGNOSIS: No scales on caudal. Outer row of teeth enlarged in lower jaw as well as in upper. Tongue with a rather broad emargination in front, continued into an abrupt narrow cleft at midline. Mental frenum not bilobed. (Anterior dorsal spine of male not known). Mouth terminal, lower jaw somewhat projecting. D. 7-12. A. 11. Ventral disk rather short, 1.8 times in distance from its base to origin of anal, 18.4% of standard length. Body markedly slender, greatest depth 16.5 %, least depth of caudal peduncle 10.2% of standard length. Head notably depressed, its depth directly behind eye 2.5 in its length, 11.8% of standard length. Maxillary about reaching a vertical through posterior margin of eye, 13%; head 29%; snout 7.7%; eye 6.9% of standard length. Barbule in front of eye, at inner edge of upper lip, small but very distinct. Anterior nostril in a short tubule; posterior nostril with a raised rim, the rim in front being continued into an expanded tiny flap fitting over opening of nostril when bent over. Lighter cross bars on body distinct but not sharply differentiated from the darker interspaces.

SIZE: Total length of single known specimen 44 mm., 36.5 mm. in standard length.

GEOGRAPHICAL DISTRIBUTION: La Paz Harbor, Mexico; the present account being based on the single type specimen collected there by the Albatross, March 12, 1889.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The present species is closely related to *histris*, but it apparently differs in having fewer fin rays, a more slender body, and a somewhat distinctive color pattern. As far as may be judged from the two specimens examined, one of each species, and bearing in mind the nature and variability of the characters which distinguish the species in *Gobiosoma* as worked out above for those species for which abundant material is available, it seems evident that the present species is distinct from *histris*. However, it is also evident that a true picture of their divergence remains to be elaborated with more extensive material. In this connection, it is interesting to note that Pellegrin (Bull. Mus. Hist. Nat. Paris, t. 7, p. 162, 1901), among other species of *Gobiosoma* or related genera, records also *G. molestum* and *G. histris* from the Gulf of California. While this author gives no description of his material, and the application of the name is certainly wrong in regard to *molestum*, yet his records suggest the presence there of two closely related

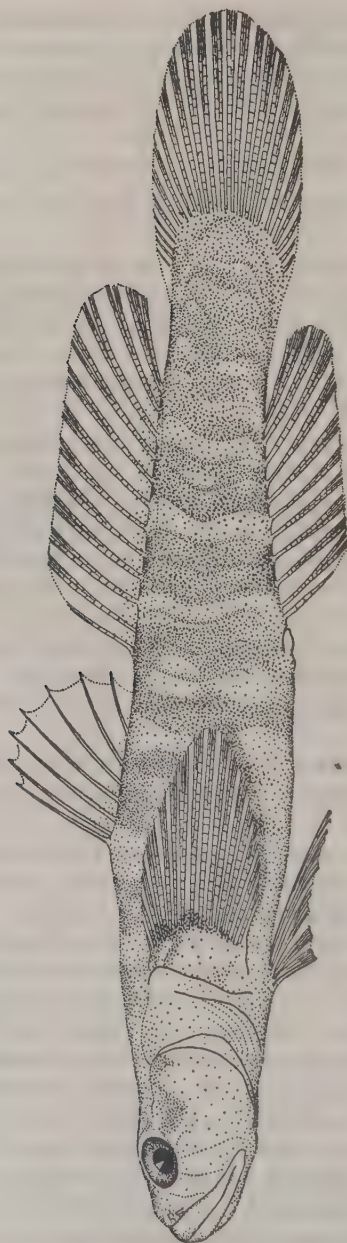


Figure 2. *Gobiosoma occidentale*, from the type specimen, a female, 44 mm. in total length. La Paz Harbor, Mexico.

species which possibly correspond to *histrion* and *occidentale*. This is, of course, merely a suggestion and may not be borne out by an examination of the material.

subgenus **Dilepidion**

Dilepidion Ginsburg, Pr. U. S. Nat. Mus. **82** (20): 17, 1933.

GENOTYPE: *Gobiosoma ginsburgi* Hildebrand and Schroeder by original designation.

DEFINITION: This subgenus differs from the subgenera *Gobiosoma*, *Nes*, *Aruma*, and *Elacatinus* in having two ctenoid scales, and two only, on the caudal fin, at its base, one above and one below. This character proved to be remarkably constant in many specimens of *ginsburgi* examined. The scales are usually firmly adherent; if fallen, their pockets are readily discernible. The subgenus *Gerhardinus* also has two scales in the same positions as on the present subgenus, but *Dilepidion* differs from it in not having the mental frenum bilobed. Outer row of teeth in lower jaw enlarged. Tongue not cleft. Anterior spine of first dorsal not prolonged. Mouth terminal. It contains two species, *ginsburgi* and *longipala*.

Gobiosoma ginsburgi

Gobiosoma bosci Smith and Bean (in part), Bull. U. S. Fish. Comm. **18**: 187, 1898 (Potomac River at Gunston Wharf, Va.; U. S. N. M. 30251, reexamined).

Gobiosoma ginsburgi Hildebrand and Schroeder, Bull. U. S. Bur. Fish. **43** (1): 324, f. 195, 1928 (Chesapeake Bay, various localities).

The following records probably refer to *ginsburgi*, that by Moore because of the depth at which the specimens were obtained, *ginsburgi* being more of an offshore species than *bosci*; the other four records because of the localities at which the specimens were obtained, the present study throwing a doubt on the occurrence of *bosci* north of Long Island.

Gobius alepidotus Linsley, Amer. Jr. Sc. Art **47**: 65, 1844 (Bridgeport, Conn.).

Gobiosoma bosci Bean, Rep. U. S. Comm. Fish. **1882**: 341, 1884 (Woods Hole, Mass.).

Gobiosoma bosci Moore, Bull. U. S. Fish. Comm. **12**: 363, 1894 (Sea Isle City, N. J., dredged in 3 to 4 fathoms).

Gobiosoma bosci Smith, Bull. U. S. Fish. Comm. **17**: 105, 1898 (Quisset Harbor, Woods Hole, Mass.).

Gobiosoma bosci Kendall, Rep. Comm. Fish. Game Massachusetts. **1910**: 150, 1911 (Tisbury Great Pond, Martha's Vineyard, Mass.).

DIAGNOSIS: Two rather strongly ctenoid scales present on base of caudal, the scale pockets attached to posterior margin of caudal peduncle, one above and one below. Outer row of teeth in both jaws enlarged. Tongue entire. Mental frenum not bilobed. Mouth terminal or subinferior, lower jaw usually somewhat included. Anterior spine of first dorsal not filamentous. First dorsal

with 7 flexible spines (24 specimens counted). Second dorsal normally with 12 rays, infrequently 13. Anal rays modally 11, often 10, infrequently 12. Length of ventral disk usually 1.3 to 1.5 in distance from its base to origin of anal, varying 1.2 to 1.5; 21 to 26% of body length. Depth medium, modally 20%, varying 17 to 22% of standard length; depth of caudal peduncle mostly 12 or 13%, varying 11 to 15% (For number of specimens studied in detail and frequency distributions, see Tables 1-6). Head moderately depressed, its depth directly behind eye less than its width, 2 to 2.3 in its length, 13 to 14% of standard length (range of 8 specimens, 31 to 42 mm. in standard length). Anterior nostril in a short tubule; posterior nostril with raised edge. Barbule in front of eye very small, almost reduced to mere pimple. Body cross-barred with alternate lighter and darker bars, the lighter bars narrower than the darker, the two usually not sharply delimited, not entirely straight; a median row of dark brown spots usually strongly marked.

CORRELATION OF NUMBER OF RAYS IN VERTICAL FINS: In the following table note that the bulk of specimens fall in a group having but one ray less in the anal than in the dorsal. In this respect then, *Dilepidion* is, on the average, somewhat intermediate between *Gobiosoma* and *Elacatinus*.

Anal rays	Dorsal rays	
	12	13
10	7	
11	28	4
12		1

SIZE: Largest specimen examined, a male from Chesapeake Bay, is 52 mm. in total and 42 mm. in standard length.

GEOGRAPHICAL DISTRIBUTION AND MATERIAL STUDIED: In addition to the original material from Chesapeake Bay, specimens were also studied from Wareham River, Mass. (U. S. N. M. 58900); Woods Hole, Mass. (U. S. N. M. 44135 and 83508); Sewells Point, N. J. (Bureau of Fisheries Coll.); Skull Creek, S. C. (U. S. N. M. 59042); Charleston Harbor, S. C. (U. S. N. M. 59016); May River, S. C. (U. S. N. M. 59089). The authenticated range of the species as now established, is therefore Wareham River, Mass., to May River, South Carolina, but it is possible that it extends to southern Florida as noted in the next paragraph. The northern limit of its range is evidently farther than that of any other species of *Gobiosoma*, there being no authenticated records of *bosci* north of Long Island (see p. 34). The species is quite common in Chesapeake Bay, altho not as abundant as *bosci*, at least in shallow water. It also appears to be fairly common at Woods Hole, Mass., and I am informed by Dr. Samuel F. Hildebrand that it is fairly common at Beaufort, N. C. As compared with

bosci the present species has a different distribution with respect to depth, ranging to deeper water. While *ginsburgi* may be taken with a drag seine along the shore, it is also taken with the trawl in deeper water, and is possibly more common at short distances offshore. On the other hand, *bosci* is taken only in shallow water along the shore.

The American Museum of Natural History has a small specimen (No. 5098), taken off Marco, Florida, Feb. 17, Tekla Expedition, which possibly belongs to the present species. The standard length of this specimen is 21 mm. (caudal broken); one scale present on base of caudal, with the pockets of two others evident, that is counting both sides together, the fourth pocket probably torn; D. 12, A. 10; ventrals 1.2 in the distance from its origin to origin of anal 24.8% of standard length. Head not markedly depressed. Color faded. The length of the ventral of this specimen falls at the extreme of the frequency distribution of *ginsburgi* and approaches that of *longipala*, but it is reasonable to expect that the ventral length of the latter species will be found to vary and, perhaps, to overlap that of the former. However, since the ventral length of *ginsburgi* varies also with the size, being relatively longer in the smaller fish, and considering the size of this specimen it seems more likely that it is an example of *ginsburgi*. The form of the head is also more like in the present species. The fin ray count is like the type of *longipala*, but sometimes specimens of *ginsburgi* have the same numbers of fin rays. The record of this specimen would extend the range of the present species; but since the color is faded and the structural characters are not decisive, the identification is not altogether certain and must wait till more abundant material of *longipala* is obtained and the difference between that species and *ginsburgi* more definitely established.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: Prior to the description of the present species by Hildebrand and Schroeder, in 1928, it was generally confused with *bosci*. In the original description it was separated from *bosci* chiefly on the basis of characters susceptible of being studied only statistically, there being a certain degree of intergradation in those characters as between the two species. Single specimens may now be placed with assurance by the presence of two scales on the caudal fin of *ginsburgi* and their absence in *bosci*. The differences in the shape of the body and the color between these two common species the ranges of which widely overlap, are such that in material which has not faded, they may be distinguished, as a rule, after one becomes familiar with their appearance. The present species is quite closely related to *longipala* differing from the latter by the shorter ventral and the color, and possibly also by an average greater number of anal rays and by the head being depressed to a lesser extent.

Nomenclature: Some measure of doubt may be raised as the proper use of the name *ginsburgi* for the present species. It is now known that at least two common species of naked gobies exist on the Atlantic Coast of the United

States. Two early names, *bosci* and *viridipallidus*, are based on specimens from South Carolina and New York, respectively, where both species occur, while the original accounts may refer to either one of those two species, more or less. The third early name, *alepidotus*, being a substitute for *bosci*, must be suppressed, of course, as a synonym of the latter. Relying solely on published accounts, it will be noted that *viridipallidus* was made a synonym of *bosci* by Cuvier and Valenciennes (1837), this action restricting both of these names to the same species; while *bosci* was definitely restricted by Hildebrand and Schroeder (1928) to one of the two common species (see p. 35). This fixes the nomenclature of the species as far as the published records are concerned. If the original specimens on which the early names were based, were still in existence the problem could be settled with finality by a study of such specimens. However, the original specimens of *viridipallidus* are obviously not now in existence, and the same is probably true for those of *bosci*. The conclusion drawn from the published accounts, or the nomenclature as used in the present paper, therefore, will probably have to stand.

Gobiosoma longipala

Gobiosoma longipala Ginsburg, Pr. U. S. Nat. Mus. **82** (20): 18, 1933 (Boca Grande, Fla.).

DIAGNOSIS: Two scales on caudal present. Outer row of teeth enlarged in both jaws. Tongue entire. Mental frenum not bilobed. Mouth nearly terminal, lower jaw being but slightly included. Anterior spine of first dorsal not filamentous in male. D. 7-12. A. 10. Ventral disk long, its posterior margin reaching to origin of anal fin, 26% of standard length (see Table 3 for comparison with other species). Depth medium, 20%; least depth of caudal peduncle 13% of standard length. Head probably much depressed and markedly flattened on top (the single specimen examined evidently thrown out of shape by spasmodic movements after capture or after being placed in preservative and consequently normal condition not altogether certain). Anterior nostril in a short tubule; posterior nostril with a raised rim. Barbule in front of eye, at inner edge of upper lip reduced to a mere pimple. End of maxillary on vertical about through posterior margin of eye, 17%; head 33%; snout 8.4%; eye 7.4% of standard length. Body from base of pectoral with 9 lighter cross bars alternated with brown bars of about same width; lighter and darker bars fairly well delimited on anterior part of body; both rather uniformly pigmented; their edges rather sinuous, not entirely straight; a median series of small dark brown spots present.

SIZE: Length of single specimen examined, 39 mm., 31.5 mm. without the caudal.

GEOGRAPHICAL DISTRIBUTION: This species is known only from the single type specimen taken at Boca Grande, Fla. Another specimen examined from Marco, Florida, may possibly belong to the present species (see p. 41).

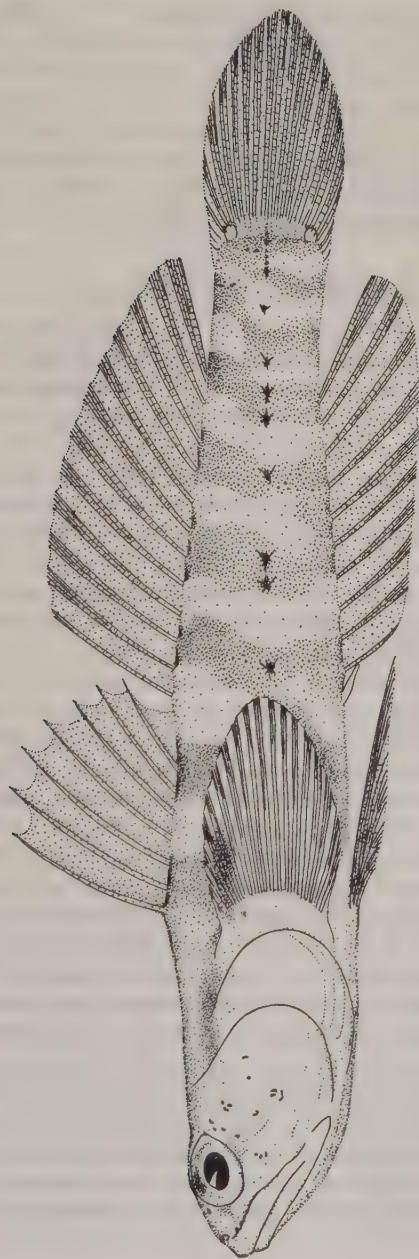


Figure 3. *Gobiosoma longipala*, from the type specimen, a male, 39 mm. in total length. Boca Grande, Florida.
Maxillary figured somewhat too long.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The present species, in common with *ginsburgi*, and unlike all other known species of *Gobiosoma* from the east coast, has two scales on the base of the caudal. From *ginsburgi* it differs chiefly in the longer ventral disk which reaches to the origin of the anal, and in the color pattern. The number of anal rays in the type specimen is one less than the mode of *ginsburgi* and an examination of a series of specimens may possibly show different frequency distributions for the two species. The head is possibly more depressed in *longipala*, but, as stated, the type is probably distorted.

***Gobiosoma parri*,¹ new species**

DIAGNOSIS: Scales present on caudal at its base. (The young specimens studied have mostly two ctenoid scales on the base of the caudal, one above and one below, in the same positions occupied by those of *ginsburgi*. A few of the larger specimens have two smaller scales between the two larger ones, making four scales in a vertical row. It is possible that in the majority of the specimens all the scales have not developed and that the species typically has four scales on the caudal. No scales are present on the body or caudal peduncle in any of those examined.) Tongue entire. Mouth terminal, lower jaw but slightly included. Mental frenum not bilobed. Teeth in bands, anterior ones but slightly enlarged in the small specimens. First dorsal not filamentous, but since only young specimens available its condition in adult uncertain. First dorsal nearly always with 7 flexible spines (in 30 specimens), infrequently 8 (in 1, the first dorsal of 1 specimen being broken). Second dorsal with 12 rays in the great majority (in 27 specimens), sometimes 11 (in 2), or 13 (in 3). Anal rays nearly always 10 (in 31), infrequently 11 (in 1). - Anal having 2 rays less than the second dorsal in the great majority (26), sometimes 1 less (in 3), or 3 less (in 3). Ventral medium, never reaching to origin of anal, its length nearly always 1.2 or 1.3 in the distance from its base to origin of anal, varying 1.1 to 1.4 times; 22.9 to 28.3 per cent of standard length (21 specimens, 16.7 to 22.2 mm. in total length measured, of which 14 specimens fall in the range 24 to 25.3%). Barbule in front of eye nearly absent, but usually perceptible as a mere pimple. Head moderately depressed. Body cross barred with 9 broad dark bands, alternated with narrower light interspaces; the bands and interspaces fairly well delimited, but boundaries not clear-cut; the bands not uniformly pigmented, mottled with lighter and darker; an incomplete, sinuous, diffuse, vertical, light colored streak,

¹ This species of which 32 young specimens only are available was discovered after the manuscript had been completed and submitted for publication. For this reason and due to the fact that its subgeneric affinities must remain in doubt until adults are studied it was not incorporated in the key. The discovery of this species also makes desirable a few minor changes, in the definition of the genus and in other places, but the text was generally left in its original form pending the discovery of adult specimens.

faintly dividing band into two parts; a transverse dark streak at base of caudal usually prominent; specimens often light colored, and cross barred pattern quite faint; a medium row of small dark spots often present, but not especially prominent, frequently very faint or absent.

DESCRIPTION AND MEASUREMENTS OF TYPE SPECIMEN: A compact, chubby, little fish with a rather deep body and caudal peduncle. Head moderately depressed, its depth behind eyes subequal to its width at that point. Interorbital quite wide. Mouth medium, moderately oblique, maxillary reaching to a vertical at a point nearly thru middle of eye. Total length 22.2 mm. Standard length 17.8 mm. Greatest depth 22.5, least depth of caudal peduncle 14.1, length of head 32, depth of head directly behind eyes 16.9, width of head at same point 16.9, postorbital part of head 18, maxillary 12.4, snout 10.1, eye 8.4, interorbital (fleshy part) 7.9, ventral 24.7, distance ventral to anal origins 31.5, pectoral 30.9, caudal 25.9 and antedorsal distance 39.3 per cent of standard length.

HOLOTYPE: U. S. N. M. 93177—Pocitos, Uruguay. Tide pool, captured by means of chloride of lime. November 8, 1922. Hugh M. Smith.

PARATYPES: 14 specimens 18.5 to 21 mm. in total length taken together with the type (U. S. N. M. 86677). Also, Piriafolis, Uruguay; tide pool; December 3, 1922; Hugh M. Smith; 17 specimens 16.5 to 19.5 mm. (U. S. N. M. 86681).

DISTINCTIVE CHARACTERS AND RELATIONSHIP: This species is evidently quite closely related to *ginsburgi* and *longipala* and differs from both in the increased number of scales on the caudal. It further differs from *ginsburgi* in that the anal rays are predominantly 10 instead of 11; and from *longipala* in the shorter ventral. Altho extreme variants approach in their ventral length that of the type of *longipala* it is to be noted that all the specimens studied are small, apparently being immature. In the species of *Gobiosoma* the ventral is generally longer in the young. Consequently, the difference in ventral length between *parri* and *longipala* is most probably greater in fact than indicated by the material studied which is not comparable as to size.

The specimens studied are apparently juveniles. Ten of the larger ones, five from each lot, which have been dissected did not show well developed gonads on examination. The structure of the anal papilla and fins also show that they are most likely young specimens. While a study of the young specimens shows that they represent an undescribed species, its subgeneric affinities are doubtful to some extent, because of the uncertainty as to whether the specimens have the squamation fully developed. In connection with this question, it may be stated that 4 specimens of *Garmannia paradoxa*, 19 to 21 mm. in length have the adult squamation fully developed. Also, in one specimen of *Enypnias seminudus*, 26 mm. long, the scales are very small and the specimen appears scaleless on superficial examination, but the scales may be readily detected by scraping the skin lightly with a dissecting needle. (This small specimen of *E. seminudus* also has the two barbels on the chin well developed, altho not as long

as in the adults.) All the young specimens of the present species, however, lack scales on the caudal peduncle. Judging by analogy, therefore, after this comparison with species of closely related genera, the probabilities strongly favor the conclusion that the present species will eventually be found to be characterized by the possession of a row of 4 scales on the caudal, at its base. Should that prove to be the case, it would seem desirable to erect a new subgenus based on that character, in order to be consistent. This new subgenus would still further narrow the gap between *Gobiosoma* and *Garmannia*. Since, however, it is not always safe to draw conclusions by analogy, this action is postponed until adult specimens of the present species are available for study.

I take pleasure in naming this species after Albert E. Parr, Curator of the Bingham Oceanographic Collection.

subgenus **Gerhardinus**

Gerhardinus Meek and Hildebrand, Publ. Field Mus. Nat. Hist. Chicago (zool. ser.) **15** (3): 889, 1928.

GENOTYPE: *Gerhardinus nudus* Meek and Hildebrand, by original designation.

DEFINITION: This subgenus, like *Dilepidion*, has two scales on the caudal fin, at its base, in the same positions as in the latter subgenus. It differs from *Dilepidion* chiefly in having the mental frenum bilobed, forming two barbule-like processes. The mental barbules represent a modification of the mental frenum which is present in all species of *Gobiosoma*—although it is usually rather indistinct in preserved specimens—while in *nudum*, the genotype of *Gerhardinus*, this frenum becomes bilobed, the lobes suggesting barbules. What is presumably a further extension of this modification, altho it may possibly represent a case of parallelism, reaches a high degree of development in *Enypnias* (see Fishes of Panama Bay by Gilbert and Starks in Mem. California Ac. Sc. vol. 4, p. 173, pl. 29, fig. 53, 1904) where the two lobes become greatly prolonged and assume the aspect of true barbels. However, *Enypnias* is covered with scales over the greater part of the body, posteriorly, it shows a tendency toward an increased number of rays in the second dorsal and is evidently further removed from *nudum* than the latter is from the other species of *Gobiosoma*. *Gerhardinus* is therefore placed here as a subgenus of *Gobiosoma*. If treated as an independent genus all the other subgenera should be so treated in order to be consistent. As stated previously (p. 14), for convenience, in order not to clutter up the nomenclature with two many generic names, they are treated here as subgenera. The present subgenus contains only one known species.

Gobiosoma nudum

Gerhardinus nudus Meek and Hildebrand, Publ. Field Mus. Nat. Hist. Chicago (zool. ser.) **15** (3): 889, pl. 88, 1928 (Balboa and Panama City, Panama).

DIAGNOSIS: Two ctenoid scales on base of caudal present. Outer row of teeth in both jaws enlarged. Tongue entire. Mental frenum bilobed forming two barbule-like processes. Mouth subterminal or subinferior, the lower jaw included. Anterior spine of first dorsal not prolonged. First dorsal with 7 flexible spines; second dorsal with 12 rays; anal with 10 rays (the counts constant in 9 specimens examined). Ventral disk of medium length, 20 to 24% of standard length, 1.3 to 1.5 in distance from its origin to origin of anal (in 7 specimens, 23 to 30 mm. in standard length). Body and head notably stout; greatest depth 24 to 28% of standard length (in 4 specimens 25 to 33 mm. in standard length), least height of caudal peduncle 13 to 17% (in 8 specimens 23 to 33 mm.). Depth of head directly behind eyes usually equals the width, frequently a little wider than deep, the depth 17 to 18% of standard length, 1.6 to 1.9 in length of head (in 8 specimens 23 to 33 mm.). Anterior nostril in a tubule, posterior nostril with the edge but slightly raised; a perceptible but very small barbule behind inner margin of upper lip, on a line with lower edge of eye; barbule somewhat shorter and broader than in subgenus *Aruma*, but better developed than in other subgenera. Body with alternate transverse bands of lighter and darker, the former narrower than the latter, the two usually not sharply differentiated; the wider bands usually not uniformly pigmented, shaded with lighter and darker; a median row of small dark spots usually present; spinous dorsal usually with a large black blotch in front, near its base; ventrals mostly black frequently with a wide, yellowish longitudinal band along middle, sometimes pigmentless.

SIZE: The largest specimen examined, a male from Paita, Peru, is 41 mm. in total and 33 mm. in standard length.

GEOGRAPHICAL DISTRIBUTION AND MATERIAL STUDIED: The above account is based on the type and 7 paratypes taken in tide pools at Balboa and Panama City on the Pacific Coast of Panama; and 1 specimen collected at Paita, Peru, by Dr. Waldo L. Schmitt, October 8, 1926 (U. S. N. M. 88786), which is recorded here for the first time. There appear to be no other records of this species.

DISTINCTIVE CHARACTERS AND RELATIONSHIP: The presence of two scales in the same characteristic positions as in *ginsburgi* and *longipala*, shows that *nudum* is quite closely related to those species, differing in having the mental frenum bilobed forming two barbule like processes, in which respect *nudum* forms a bridge between *Gobiosoma* and *Enypnias*. No other species of *Gobiosoma* are now known from the geographical range inhabited by *nudum*. From the two most closely related gobies occurring within its range, namely, *Enypnias seminudus* and *Garmannia paradoxa*, the present species is readily distinguished by the total absence of scales on the posterior part of the body. The short deep body and caudal peduncle of *nudum* are quite conspicuous.

SEX RATIO IN GOBIOSOMA

Some interesting observations were made in connection with the present study, on the sex ratio of the common species. Since no further studies along this line are contemplated in the near future and since these fishes are common and offer excellent material for sex ratio studies a record of these observations is given here, altho they are of but a fragmentary nature.

Presumably the sexes may be distinguished externally by the structure of the anal papilla. In the male the anal papilla is in the form of a triangular, somewhat compressed and pointed, flap. In the female it is somewhat shorter and thicker and has the form of a truncated cone. In the latter sex also, the opening of the anal papilla is fimbriated, the fimbriae being especially developed laterally, so that when examined with a lens of low power, it characteristically appears like a truncated cone having a short raised "horn" laterally which is often blackish in color. After one becomes familiar with the difference in structure, the specimens may be separated readily into two groups on that basis, with only occasional doubtful cases. This difference was checked by a microscopic examination of the gonads of 10 immature females, 15 males in various stages of development, and also by an examination of 35 ripe females in which the eggs could be identified with the naked eye. The sexual difference in the structure of the anal papilla as described checked with the examination of the gonads in every specimen.

Assuming that the external criterion as described above holds in every case, part of the material examined, representing collections made in different localities and on different dates, were sexed by that criterion, with the following result.

species	sex	
	male	female
<i>ginsburgi</i>	25	10
<i>robustum</i>	18	3
<i>bosci</i>	230	72

The above striking difference in the sex ratio represents a composite lot of fish in all stages of development, from immature fish to those which have spawned out. However, the material sexed indicates a possible change of the sex ratio after spawning. For example, in a lot of fish collected in the Rappahannock River, Va., July 23 to August 1, 1921, the sex ratio is 41 females to 74 males. The great majority of specimens in this lot are mature fish, ready to spawn; the rest being small and immature specimens. On the other hand, in three lots of spent fish, as follows: Love Point, Kent Island, Md., Sept. 2-6, 1921; Norfolk, Va., Sept. 30, 1921; York River, Va., Oct. 11, 1921; the sex

ratios are: no females and 25 males; no females and 18 males; 8 females to 35 males, respectively. It may be suggested that the sexual difference in the structure of the anal papilla disappears largely after spawning, but this seems unlikely. In the few spent fish of which the gonads were examined microscopically, the sex cells were found to be correlated with the sexual difference in the structure of the anal papilla as described. A possible explanation for the change in the sex ratio after spawning is that the great majority of females die soon after spawning, at least they die in greater numbers relative to the males.

A preponderance of males seems to be present also in related species as may be seen under the accounts of *Gobiosoma horsti* (p. 24), and *Garmania paradoxa* (p. 56).

Dr. Samuel F. Hildebrand who kindly read the manuscript, criticised the value of the data showing striking differences in the sex ratio, raising an important point, as follows. In preserved collections of these gobies the females appear to average smaller than the males, at least the maximum size of females usually falls considerably below that of males. Consequently, since the gear used, and especially the size of the mesh of the nets used, in collecting much of the material sexed, was unknown, the apparent difference in the sex ratio may be due to the difference in the size of the two sexes. The females, ostensibly averaging smaller, might have escaped thru the meshes in greater proportion than the larger males. In consequence of this criticism, some of the specimens of *bosci* available in the Bureau of Fisheries' collections which were sexed, as indicated, were also measured for total length and the length-frequency distribution of the two sexes is tabulated below. The lengths as tabulated are grouped into 5 millimeter classes, the heading numbers representing mid-values; for instance, class 17 represents specimens ranging 15 to 19 mm. in length, etc. The tabulated data show that at every size the males far outnumber the females, whereas if the sexes were in approximately equal numbers in nature the males should be in lesser numbers, if anything, in the smaller size classes.

	Length in millimeters (mid-values).									
	17	22	27	32	37	42	47	52	57	62
Number of males	1	19	28	39	56	47	25	13	1	1
Number of females	2	3	5	14	22	24	2			

Another interesting point is revealed by the foregoing data. It will be noted that the frequency polygon for males will assume a quite regular form, while that for females will be strikingly skewed. As a consequence of the skewed grouping of females, the simple average is nearly the same in both sexes—35.3 mm. for females and 36.8 mm. for males as calculated from the original data before they were grouped—altho many males attain to a considerably larger size than the maximum attained by the females. While this phenomenon may arouse certain speculations, this study, of course, has not been carried far enough

to enable one to offer, with assurance, any explanation, except to bring forth the suggestion already offered; namely, that the majority of females die soon after spawning. In that case, the numerous larger males attaining a size greater than the maximum attained by females, are possibly larger because they are a year older. However, the specimens sexed and measured are certainly too few; moreover, they possibly do not represent a fair sample of the population to enable us to advance an acceptable explanation in regard to the difference in the length-frequency distribution of the two sexes.

UNCERTAIN REFERENCES

The references to the literature given above under each species are based on material which has been reëxamined, or those which from their contents it is apparent to which species they refer. However, it is evident from the foregoing discussions that the species have been considerably confused and in many cases records of material can not be placed with certainty, unless the material on which the records are based is reëxamined. In order to make the study of the genus as complete as possible, such uncertain references have been compiled and classified below according to their probable appertenance, as judged by the conclusions arrived at as a result of the present investigation.

The following citations probably refer chiefly to either *bosci* or *ginsburgi*, or to both, the two species not having been distinguished prior to 1928. Both species are more or less common in the region to which the records refer, the specimens on which the records were based have not been examined; and from the accounts it is not evident to which particular species they refer.

Gobius alepidotus De Kay, Zool. New York, **4** (Fishes): 160, pl. 23, f. 70, 1842 (New York).

Gobius alepidotus Baird, Ann. Rep. Smithsonian Inst. **1854**: 339, 1855 (Beesleys Point, New Jersey).

Gobiosoma alepidotum Gunther, Cat. Fish. Brit. Mus. **3**: 85, 1861 (New York to Charleston).

Gobiosoma alepidotum Abbott, Geol. New Jersey by G. H. Cook, app. E, p. 817, 1868 (Delaware Bay).

Gobiosoma alepidotum Jordan and Gilbert, Bull. U. S. Nat. Mus. **16**: 638, 1882 (South Atlantic Coast of United States).

Gobiosoma bosci Jordan and Gilbert, Pr. U. S. Nat. Mus. **5**: 613, 1883 (Charleston, S. C.).

Gobiosoma bosci Jordan, Pr. U. S. Nat. Mus. **9**: 28, 1886. (Beaufort, N. C.).

Gobiosoma bosci Bean, Bull. Amer. Mus. Nat. Hist. **9**: 370, 1897 (Eaton's Neck, Long Island).

Gobiosoma bosci Bean, Ann. Rep. For. Fish. Game Comm. New York **6**: 460, 1900 (Long Island, N. Y.).

- Gobiosoma bosci* Bean, Cat. Fish. New York, p. 656, 1903 (New York).
Gobiosoma bosci Smith, Fish. North Carolina, p. 368, 1907 (North Carolina).
Gobiosoma bosci Fowler, Pr. Ac. Nat. Sc. Philadelphia **61**: 407, 1909 (Corson's Inlet, N. J.).
Gobiosoma bosci Evermann and Hildebrand, Pr. Biol. Soc. Washington **23**: 163, 1910 (Blackstone Id.; Cape Charles City; Gloucester Point; Hampton Creek, all in Chesapeake Bay).
Gobiosoma bosci Latham, Copeia **31**: 40, 1916 (Orient Bay, Long Island).
Gobiosoma bosc Fowler, Pr. Ac. Nat. Sc. Philadelphia **69**: 126, 1917 (Rhodes River, and mouth of South River, Md.).
Gobiosoma bosc Fowler, id., **71**: 300, 1919 (Cape Charles, Va.).
Gobiosoma bosci Fowler, id., **72**: 391, 1920 (Barrow Creek, tributary of Rhodes River, Md.).
Gobiosoma bosc Fowler, id., **74**: 8, 1922 (Rhodes River, near Mayo, Md.).
Gobiosoma bosci Nichols and Breder, Zoologica **9**: 155, fig., 1927 (Orient, N. Y.; Woods Hole, Mass.).
Gobiosoma bosci Nelson, Natural History, New York, **28**: 78-84, 1928 (notes on habits).
Gobiosoma bosci Breder, Copeia **1931**: 40 (lower Shrewsbury River, N. J.).

The following citations probably refer chiefly either to *bosci* or to *robustum* or to both, for the same reasons as given above.

- Gobiosoma molestum* Putnam, Amer. Nat. **8**: 233, 1874 (Louisville, Ky. The locality given is probably erroneous, no other record of a naked goby being taken so far inland in the United States, being known).
Gobiosoma molestum Eigenmann and Eigenmann, Pr. California Ac. Sc. (2) **1**: 72, 1888 (Louisville, Ky.; Pensacola, Fla.; Bahia; specimen from Bahia reexamined and found to be a *robustum*, others not examined).
Gobiosoma molestum Fowler, Copeia **1931**: 50 (Laguna Madre, Texas. The maximum size recorded, 80 mm., is considerably larger than any of the many specimens of either *bosci* or *robustum* examined by me).

The following citations may refer, partly or wholly, to one or more of five species which occur within the range covered by the records, as indicated by the present investigation; namely, *bosci*, *robustum*, *ginsburgi*, *longipala*, and *longum*, the species not having been distinguished by authors at the time the records were made, as in the preceding doubtful records. Three references in which the authors definitely express the opinion that all naked gobies of the east coast belong to one species, are also included.
Gobiosoma alepidotum Jordan and Gilbert, Pr. U. S. Nat. Mus. **5**: 297, 1882 (Laguna Grande, Pensacola, Fla. The specimens recorded reexamined and found to be *robustum*; but the authors evidently being of the opinion that all common naked gobies of the east coast of the United States belong to a single species).

Gobiosoma bosci Jordan and Gilbert, Bull. U. S. Nat. Mus. **16**: 948, 1882 (all naked gobies on the coast of the United States lumped as one species).

Gobiosoma bosci Jordan, Pr. U. S. Nat. Mus. **7**: 141, 1884 (Key West, Fla.).

Gobiosoma bosci Jordan, id., p. 324 (Indian River, Fla.).

Gobiosoma bosci Jordan and Eigenmann, Pr. U. S. Nat. Mus. **9**: 508, 1886 (Cape Cod to Florida).

Gobiosoma molestum Jordan and Eigenmann, id. (Gulf coast of United States, Key West to Texas).

Gobiosoma bosci Eigenmann and Eigenmann, Pr. California Ac. Sc. (2) **1**: 72, 1888 (Somer's Point, N. J.; Fortress Monroe, Va.; Charleston and Hilton Head, S. C.; Amelia Id., Fla.).

Gobiosoma molestum Jordan and Evermann, Bull. U. S. Nat. Mus. **47** (3): 2258, 1898 (Key West to Texas and Bahia).

Gobiosoma bosci Jordan and Evermann, id., p. 2259 (Cape Cod to Florida).

Gobiosoma bosci Jordan and Dickerson, Pr. U. S. Nat. Mus. **34**: 21, 1908 (Authors express opinion that all naked gobies of east coast belong to one species; their one specimen from Tampico is, however, a true *bosci*).

Gobiosoma bosci Fowler, Copeia **43**: 39, 1917 (Boca Grande, Fla.).

GARMANNIA

This genus is very similar to *Gobiosoma* in nearly all essential characters, as the latter genus is defined above. *Garmannia* differs chiefly in having the posterior part of the body more or less covered with scales instead of lacking such scales, and in having four scales on the caudal fin in a transverse row, at its base, instead of two or none as in *Gobiosoma*.¹ The first ray of the spinous dorsal in the available adult males of two of the species examined is filamentous, sometimes also in large females as an individual variation, while in *Gobiosoma* this character is developed, to a less marked extent, only in *longum*.

The genus is here divided into three subgenera, *Tigrigobius* being transferred from *Gobiosoma* to *Garmannia* and a new subgenus is described. The available material is insufficient for the preparation of a complete revision, but the accounts furnished herewith together with those to which references are given should form a working summary of the genus.

subgenus *Tigrigobius*

Tigrigobius Fowler, Pr. Ac. Nat. Sc. Philadelphia, **83**: 401, 1931.

GENOTYPE: *Gobiosoma macrodon* Beebe and Tee Van, by original designation.

DEFINITION: *Tigrigobius* was originally proposed as a subgenus of *Gobiosoma*, based largely on the color and the filamentous first dorsal spine. A more

¹ *Gobiosoma parri*, a new species discovered after the above was written (see p. 44) seems to have a row of four scales on the caudal fin while lacking scales on the caudal peduncle, thus further narrowing the gap between *Garmannia* and *Gobiosoma*.

important character, however, is the presence of scales, four in a vertical row on the caudal, at its base, and a small patch on the middle of the caudal peduncle at the base of the caudal fin (see diagnosis of *macrodon*). The presence of scales on the caudal peduncle, and their number on the caudal fin, 4 instead of 2, shows that this subgenus is more nearly allied to *Garmannia* than to *Gobiosoma*. On the other hand, in the reduced number of scales it forms a transition from one genus to the other. *Tigrigobius* differs essentially from typical *Garmannia* in having the scales on the hind part of the fish very much reduced in number and confined to the caudal peduncle. The outer row of enlarged teeth in the upper jaw is confined to the anterior part of the jaw and ends abruptly, the hindmost one being the largest; while in typical *Garmannia* as well as in *Gobiosoma*, the outer row of enlarged teeth in the upper jaw is continued to the angle of the mouth. Two to four caninoids in the inner row of lower jaw are conspicuously large and suberect; while in typical *Garmannia*, as well as in *Gobiosoma* (except in the subgenus *Elacatinus*) they are smaller and rather inclined to the horizontal. The head in the present subgenus is compressed instead of being depressed. Of related species, *Gobiosoma nudum*, *G. horsti*, and *G. robustum*, especially the former two, approach it in this latter character. Like in typical *Garmannia* the present subgenus has a transverse row of 4 scales on the caudal, at its base, and the first ray of the spinous dorsal is filamentous in males, sometimes also in females. There are good grounds for treating *Tigrigobius* as a full genus; but, as stated previously, if this course is adopted *Dilepidion*, *Gerhardinus*, as well as the other subgenera herewith placed in *Gobiosoma* should also be treated as full genera, in order to be consistent. They are all treated as subgenera on the ground of convenience.

Garmannia macrodon

Gobiosoma multifasciatum Metzlaar, Rap, Kolonie Curaçao, p. 139, 1919 (Curaçao).

Gobiosoma macrodon Beebe and Tee-Van, Zoologica, **10**: 226, fig., 1928 (Port-au-Prince, Haiti).

Gobiosoma macrodon Fowler, Pr. Ac. Nat. Sc. Philadelphia, **83**: 401 (1932) 1931 (Monos Island, Trinidad).

Gobiosoma multifasciatum Koumans, A Preliminary Revision of the Genera of Gobioid Fishes with United Ventral Fins, Drukkerij "Imperator" N. V., Lisse, p. 53, 1931 (Curaçao).

DIAGNOSIS: Four scales in a transverse row on the caudal fin at its base. A small elongate patch of imbricate and ctenoid scales centered on caudal peduncle, near base of caudal fin, consisting of three longitudinal rows, 3 to 4 scales in each row; scales sometimes more or less deciduous, their pockets usually discernible on falling. Tongue entire. Mental frenum without free border posteriorly, not bilobed. Teeth in bands, several front teeth of outer row,

in both jaws, enlarged; hindmost one of enlarged teeth of upper jaw conspicuously large and recurved, caninoid; one or two caninoids in inner row of lower jaw, about midway between symphysis and angle of mouth. First ray of spinous dorsal filamentous in males (4 specimens, 25 to 35.5 mm. total length), sometimes also in females (in 1 specimen out of two examined, 23 mm. in total length), reaching to base of fifth or sixth ray of second dorsal. Second dorsal with 11 or 12 rays (11 in 4, 12 in 2 specimens); anal rays usually 10, sometimes 11 (10 in 5, 11 in 1 specimen); the second dorsal having one or two rays more than the anal. Ventral rather long 23 to 28% of standard length, 1.1 to 1.4 in distance from its base to origin of anal. Head rather compressed, the depth directly behind eyes, greater than its width, 1.5 to 1.6 in its length, 18 to 20% of standard length. Body quite chubby, greatest depth 22 to 26% and least depth of caudal peduncle 13 to 15% of standard length. Maxillary 13 to 15% of standard length, reaching to a vertical thru posterior margin of pupil or eye or slightly beyond. (The above measurements based on 6 specimens, 18.3 to 29.1 mm. in standard length, 23 to 35.5 mm. total length.) Anterior nostril ending in a short tubule; posterior nostril with a raised rim; no barbules. Ground color a rather light tan with numerous dark brown, clear cut, cross-streaks; 10 to 14 on body and 3 or 4 on head; those on head more or less curved on dorsal aspect, and sometimes continued as series of spots on under side of head, anterior one or two usually confined to space under eye; some of posterior ones on body may be forked; the last one at base of caudal sometimes broken into two elongate spots.

The scales are more or less deciduous. In the type specimen most scales have fallen off. One scale is now present on the base of the caudal at the upper profile, on the right side; one at the lower profile, on the left side; and one on the caudal peduncle of the right side. Some of the pockets become plainly evident on raising their edges carefully with a dissecting needle, showing that the scales were originally present in three longitudinal rows on the caudal peduncle and one vertical row at the base of the caudal fin. In the 5 other specimens examined, the smallest one, 23 mm. total length, has only one small scale altogether, on the caudal peduncle, but some of the scale pockets are discernible; while the other 4 specimens all have a vertical row of 4 scales on the caudal, at its base, and three longitudinal rows on the caudal peduncle. The vertical row of 4 scales on the caudal is complete in the 4 specimens, but some of the scales on the caudal peduncle are missing.

This species may be recognized at a glance by the color pattern, the many clear cut, narrow, dark streaks stand out very prominently against the lighter background, quite unlike the color of related species. The presence of a patch of scales on the caudal peduncle and the filamentous first dorsal ray show that its affinities are nearer to the species currently placed in *Garmannia* rather than to those of *Gobiosoma*.

The foregoing account is based on the type and 5 specimens in the U. S. National Museum, all taken by the Fish Hawk, as follows: Deadman's Bay, Florida; 25 mm. (U. S. N. M. 73093). N. of Knight's Key, Florida; January 22, 1903; 7 fathoms; 23 and 23.5 mm. (73094). Off Cape Sable, Florida; December 18, 1902; 4½ fathoms; 33 mm. (73095). Pepperfish Key, Florida; 27 mm. (73096). Judging by the collection made by the Fish Hawk, it does not appear to be rare just offshore. The known geographical distribution of this species, as now established, is southern Florida; Haiti; Trinidad. The type 35.5 mm. in total length is the largest specimen studied.

Metzlaar in his short description of *Gobiosoma multifasciatum* states, "seventeen exceedingly distinct cross bands; no red line on head." This statement applies more nearly to the present species and Metzlaar's specimens most probably belong to *macrodon*. Koumans' record apparently is based on the same three specimens studied by Metzlaar, the later author stating: "When I examined 3 specimens of *G. multifasciatum* Steind. from Curacao, I found some moderate, distinctly ctenoid scales on the caudal peduncle, extending forwards to the end of D 2 and A." If Metzlaar's specimens in fact belong to the present species his record would extend its range to Curaçao.

Garmannia digueti

Gobiosoma digueti Pellegrin, Bull. Mus. Hist. Nat. Paris 7: 165, 1901 (Gulf of California, in floating sargassum).

Judging by the description of the color and the filamentous first dorsal spine, this species is, most likely, the Pacific Coast counterpart of *macrodon*, and possibly belongs to the same subgenus, *Tigrigobius*; altho, like in the original account of *macrodon*, it is also described as scaleless. From the description it is not evident in what respects it differs from *macrodon*; and the differences in the two species will have to be worked out by direct comparison of material, which is unavailable at present. The other new species, *Gobiosoma pantherinum*, described in the same paper, evidently belongs neither to *Gobiosoma* nor to *Garmannia* (see p. 17).

subgenus **Garmannia**

Garmannia Jordan and Evermann, Pr. California Ac. Sc. (2) 5: 497, 1895.

GENOTYPE: *Garmannia paradoxa* (Gunther) = *Gobius paradoxus* Gunther, by original designation.

The differences between this subgenus and *Tigrigobius* as well as *Risor* are described in the accounts of the latter (pp. 52 and 56).

Garmannia paradoxa

Gobius paradoxus Gunther, Pr. Zool. Soc. London, p. 372, 1861 (West coast of Central America).

Garmannia paradoxa Gilbert and Starks, Mem. California Ac. Sc. 4: 172, pl. 28, fig. 52, 1904 (Panama).

Garmannia paradoxa Meek and Hildebrand, Publ. Field Mus. Nat. Hist. (zool. ser.) 15 (3): 890, 1928 (Panama).

This common species has been described and figured by Gilbert and Starks and described again by Meek and Hildebrand and is not treated here in detail; but the number of spines in the first dorsal and the filamentous condition of the first spine are discussed since the former character is of generic importance, while the latter is at least of subgeneric value in this group of gobies.

In regard to the first spine Gilbert and Starks state: "The first dorsal spine is constantly produced into a filament, which usually fails to reach the middle of the soft dorsal, but extends beyond the first dorsal ray." According to Meek and Hildebrand this is a sex character, these authors stating, "the rays all short in the female, the first spine filamentous in the male." In the specimens examined the filamentous condition of the first spine was found to be a sex character, being present in the male; and, furthermore, it is an age character, being present only in grown individuals. For instance, in a lot of fish in the National Museum from Panama, collected by Dr. C. H. Gilbert (U. S. N. M. 50369), the sex was determined by the structure of the anal papilla, as described above for *Gobiosoma* (p. 48). This lot contains 13 females and 17 males. Of the female specimens, 11 are 20 to 27 mm. in total length, the other two being 32 and 33 mm. In all of these the first ray is not at all filamentous, not reaching origin of second dorsal, and is somewhat shorter than the succeeding two rays. Of the males, 7 are 19 to 27 mm. and 10 range in length from 30 to 35 mm. In the group of smaller males the first ray is very long in one, reaching to the base of the eighth ray of the second dorsal, moderately prolonged in another reaching to base of second ray, while in 4 others it does not quite reach the origin of the second dorsal (broken in one specimen). In the group of larger males, the first ray reaches to the base of the fourth to the ninth ray of the second dorsal, except in one specimen (30.5 mm.) in which it attains only to the origin of the second dorsal.

The number of spines in the first dorsal in the same lot of fish, was found to be 7 in 28 individuals and 6 in only 1 (the dorsal broken in one specimen). Gilbert and Starks found that all their specimens also had 7 dorsal spines. The number of spines is, therefore, quite constant like in the species of *Gobiosoma*. In its general appearance this species resembles markedly those belonging to *Gobiosoma*, and it may possibly be more related to the species of that genus than *Garmannia macrodon*.

Risor, new subgenus

GENOTYPE: *Garmannia binghami* Parr.

DEFINITION: Caudal peduncle and posterior part of body scaled, the scales covering nearly entire surface to a level through about middle of second dorsal

and anal and extending further forward in a wedge-shaped manner to a point on midline nearly under origin of second dorsal; 4 scales in a transverse row on caudal, at its base; 2 to 4 fang-like, movable teeth present in upper and lower jaw, at the symphysis.

In its squamation the present subgenus is nearly the same as in typical *Garmannia*, the scales, however, not extending quite as far forward at the upper and lower profiles, and not quite extending to the base of the dorsal, or both dorsal and anal. It differs chiefly from the subgenus *Garmannia* in having movable canines in front. From *Tigrigobius* it differs in the more extensive squamation and also in having the movable canines in front of the jaws. Should the peculiar structure of the mouth and lips prove to be constant and diagnostic (see account of *binghami*), this character would form another difference by which to distinguish the present subgenus from the two older subgenera. Besides the type species, the present subgenus apparently includes also *rubra* and *hemigymna*.

Garmannia hemigymna

Gobius hemigymnus Eigenmann and Eigenmann, Pr. California Ac. Sc. (2) 1: 66, 1888 (West Indies).

The pertinent characters given in the original description of the type specimen, $1\frac{3}{4}$ inches long, are: "D. VI-10; A 8. Scales . . . 17 series developed . . . the maxillary reaching beyond posterior rim of orbit; lower jaw slightly shorter than the upper; teeth in the upper jaw in a band, the outer series remote, and the teeth several times as large as in the inner row, all more or less movable; teeth in the lower jaw similar, a recurved canine on each side near the front. Scales very weakly ctenoid, covering only the sides of the posterior half of the body, not extending quite to base of dorsal and anal fins even at their posterior insertion, the upper and lower edges of caudal peduncle being likewise free from scales, the scaly region, however, being widest on the peduncle and tapering forward to the central point opposite the beginning of the anal, where the scales are smallest. First spine of the dorsal not elongate. . . . Color light olivaceous . . . eight faint cross bars from dorsal to middle of sides, which, close under dorsal fins, are formed of two blackish dots; eight black dots along lateral line . . . fins all smutty . . ."

The above quotation makes it seem likely that the present species belongs to the subgenus *Risor*. It differs from *binghami* and *rubra* in the fewer fin rays, possibly in the large mouth, and in the presence of faint cross bars and two lengthwise rows of blackish dots. The scalation is apparently less extensive than in *binghami* which has the lower profile of the caudal peduncle covered with scales.

It is to be noted that *hemigymna* is described as having 6 dorsal spines. Should this number prove to be correct and constant it would be necessary to

erect a new subgenus, since the number of spines in the other subgenera of *Garmannia* as well as in those of *Gobiosoma* is pretty constantly 7.

Garmannia binghami

Garmannia binghami Parr, Bull. Bingham Oceanog. Coll. 3 (4): 124, f. 34, 1930 (Crooked Island, Bahamas).

DESCRIPTION OF TYPE: Four scales in a transverse row on caudal fin at its base, of nearly same size as scales on body. Ctenoid scales on caudal peduncle extending forward on posterior part of body to a point on midline nearly under origin of second dorsal, thence bare triangular areas extending backward, above and below, nearly to middle of second dorsal and anal; posteriorly scales extending to base of anal and on lower profile of caudal peduncle, but not quite to base of dorsal nor on upper profile of caudal peduncle. Scales but moderately overlapping on caudal peduncle, becoming nearly non-imbricate anteriorly. Structure of lips, mouth, and anterior teeth very peculiar. Upper lip with a broadly wedge-shaped indentation at tip of snout with the apex of the wedge upward, a similar indentation on lower lip, with the apex downward; the two indentations forming a roughly quadrangular fossa when mouth is closed. Lips quite broad, upper lip with a deep invagination only at the side, in the middle nearly continuous with the skin of rest of head, separated by a mere, lengthwise depression; no distinct mental frenum from lower lip evident. (The single specimen examined is well preserved and the peculiar structure of the lips and mouth seems to be the normal condition in this species. However, in view of this unusual configuration final judgement in regard to it must be held in abeyance until more specimens are studied. This apparent structure may possibly be due to preservation, but it is to be noted that the published figure of *rubra* suggests also the presence of this condition.) Mouth distinctly inferior. Cheeks very tumid and bulbous. Comparatively long and slender, recurved fang-like teeth projecting into fossa described above, two at symphysis of upper jaw, and three somewhat smaller ones from lower jaw (rest of dentition not possible to describe without injury to type specimen). First ray of spinous dorsal not filamentous in the single small specimen examined. First dorsal with 7 flexible spines, second dorsal 12, anal 10. Ventral disk rather long, nearly reaching anus, 26% of standard length, 1.2 times in distance from its origin to origin of anal. Body of medium depth 18.4%; caudal peduncle rather deep 15.3% of standard length; head 26.3%. Head directly behind eyes slightly deeper than wide, the depth 1.6, the width 1.7 in its length. End of maxillary under posterior margin of pupil. Anterior nostril distinctly tubular, posterior nostril with its rim hardly raised; no perceptible barbule in front of eye. Color of head and body uniformly dusky, without any distinctive marks, being nearly evenly sprinkled with minute chromatophores; vertical and ventral fins very dark, nearly black; pectoral and caudal dusky; body and fins with a faint purplish cast.

The above account is based on the type, the only known specimen, a male, 22.5 mm. in total length, 19 mm. without the caudal. It is quite possible that it represents a young fish. Due to the peculiar structure of the mouth and lips, and the head in general, it has a peculiarly distinctive physiognomy which may be readily appreciated on direct comparison with *macrodon* and *paradoxa*, from which it also differs in the scalation, the dentition, the color pattern and other characters. Its probable relation to the other two species of *Garmannia* from the West Indies of which no material is available, is discussed under their accounts.

Garmannia rubra

Garmannia rubra Rosen, Act. Univ. Lund. (n. f.) afd. 2, vol. 7, Contr. Faun. Bahamas, p. 63, figs. 1a and 1b, 1911. (Mastic Point, Andros, Bahama Ids. "Several specimens were collected among sponges, corals, etc.")

The pertinent characters given in the original description are: "D. VII, 12-13. A. 10. Head and anterior part of body naked; posterior part of body covered with ctenoid scales. . . . Mouth small. Maxillary extending to below anterior border of eye. Lower jaw with a band of small conic teeth outside of which are two large outwards curved teeth on each side of the median line. The upper jaw with similar dentition but only one curved tooth on each side. . . . Brownish red. Length about 2 cm."

The above quotation makes it seem apparent that this species is related to *binghami*, the only difference which may be gathered from the original description being the shorter maxillary. Considering that the specimen described was much larger than the type of *binghami* this difference takes on added significance. The published photograph shows a relatively shorter ventral than *binghami* but this may be due to its larger size. While it is possible that the two names will have to be synonymized eventually, this is not at all certain, the short description and poor figure of *rubra* not admitting of this course to be taken with assurance. It is possible that other differences will be found on direct comparison.

REPORT ON EXPERIMENTAL USE OF A TRIANGULAR TRAWL FOR BATHYPELAGIC COLLECTING*

WITH AN ACCOUNT OF THE FISHES OBTAINED AND A REVISION
OF THE FAMILY CETOMIMIDAE

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INTRODUCTION AND GENERAL DISCUSSION OF METHOD

During the first Caribbean cruise of the "Atlantis," sponsored jointly by the Woods Hole Oceanographic Institution and by Yale University, several experiments were made to test the practicability and usefulness of making deepsea tows with a large triangular trawl, measuring 50 feet along each side of the opening, a gear of this type having been provided for the purpose by the Bingham Oceanographic Foundation of Yale University.

While special mechanical difficulties in the equipment and arrangements for handling the trawl from the ship impeded the use of this large net under the circumstances under which it was tried, one of the trawling attempts nevertheless followed a normal course and yielded a result, to be reported upon on the following pages, which adequately proves the advantages of using this large gear for bathypelagic collecting to supplement the results obtained from the smaller nets. The obstacles encountered in these first experiences with the three-cornered trawl employed in deepsea towing were all of a nature which could easily be corrected in port but could not be remedied underway, and the great success of the one unobstructed haul made during this single cruise in spite of the difficulties met with on board must therefore be taken as a very promising sign for the future use of the gear.

As already mentioned, the trawl net itself measured 50 feet along each side of the opening, between the otter boards, being hung on a steel wire with manilla seizing of $2\frac{1}{2}$ inch circumference. The total length of the net was 36.9 meters (128 feet), the last 4 meters (13 feet) being a straight cod-end with 8 mm. (5/16 inch) mesh from knot to

* Contribution No. 35, Woods Hole Oceanographic Institution.

knot, the rest of the net being tapered with meshes decreasing from 25 mm. (1 inch) from knot to knot in, roughly, the first 40 feet of the length through 20 mm., 15 mm., and 12 mm. to 10 mm. in the last section before the cod-end. Cotton twine was used throughout, and the net was untanned (by misunderstanding) when the hauls were made. The dimensions of the two bottom otter boards were 200 x 110 x 5 cm. (78 x 43 x 2 inches) with a 78 x 6½ x 2 inch iron keel apart from iron half-rounds around the edges and a heavy pair of hinged rod-iron bridles for attachment of the wire-bridle, giving each trawl board a net weight of 167 kilograms (368 lbs.) when dry. The third (top) otter board was smaller and lighter, without iron weight, measuring 120 x 80 x 3 cm. (47 x 31½ x 1⅜ inch) and weighing only 55 kilograms (121 lbs.). The total weight of the three otter boards in dry condition thus adds up to 857 lbs. and exceeds 1000 lbs. after they have once been used for deepsea towing, and this weight was perhaps the greatest difficulty in handling the gear during the cruise, since a winch-boom was not yet available on the ship. The net was attached to the main towing cable by three bridle ropes 45 meters (147½ feet) long of galvanized steel wire 14 mm. (ab. 9/16 inch) circumference.

The accompanying diagrammatic sketch gives a general idea of the relative dimensions and appearance of trawl and ship.

It is believed that the length of the net might be reduced to about 75 feet, and also that the bottom trawl boards might be made much lighter and probably also somewhat smaller without any loss in fishing efficiency, but with great gains in the ease of handling. This, however, will be a matter for future experimentation, but as a general rule the chief requirements for the convenient handling of a three-cornered trawl of these large dimensions for deep-sea towing from a single cable may be stated to be the following: (1) a trawling boom or gallows well forward at the side of the ship; (2) trawling blocks in the boom and guide blocks on deck for guiding the wire to the winch with sheaves of sufficient capacity to permit the bridle to be paid out gradually and to be brought back on board in one continuous haul without necessitating attachment and detachment from the main cable overboard, i. e., after, respectively before, it has passed the last block in the trawl boom; (3) a winch boom well aft from which the otter boards can be lowered with room for the bridle to spread from the trawl boom sufficiently to permit the net to open enough to keep from tangling before it is completely "set," i. e., before the third otter board is released.

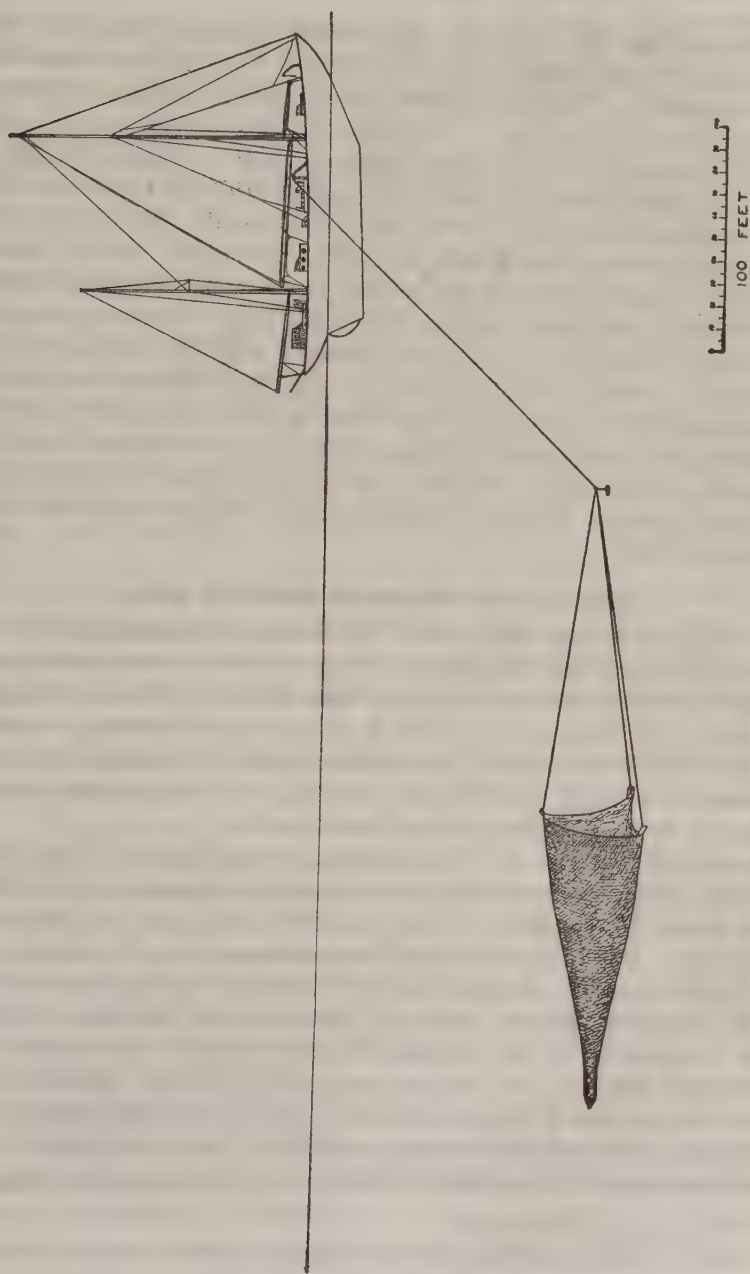


Figure 1. Diagrammatic sketch of research ship Atlantis with 50-foot triangular trawl in tow near surface.

When setting the trawl the ship should be going ahead at slow speed and turning sharply in circles towards the side from which the net is lowered. The bag (cod-end) should first be thrown overboard and permitted to trail out. Thereupon the two bottom otter boards should be lowered and released simultaneously in correct positions from the winch boom aft, with only enough bridle to reach from the trawl boom to the point where they are lowered. After they have spread as much as this length of bridle will permit, the top board should be lowered slowly to the surface and released after the bottom boards have gone down enough to remain clear. This may require that some bridle is paid out simultaneously with the lowering of the top board. After all three boards have thus been released and the net has been observed to be clear, the brakes on the trawl winch should be loosened and the net should be permitted to pull out its own cable, or if power is required, it should be so adjusted that there is always sufficient strain on the cable to keep the net open also when the cable is being paid out.

RESULTS AT ATLANTIS STATION 1478

At Atlantis Station 1478, in $25^{\circ} 39'$ Northern Latitude and $77^{\circ} 18'$ Western Latitude the triangular trawl was lowered to about 1050–1100¹ meters vertical depth and trawling begun at 3:55 P. M. on February 20, 1933. On February 21 at 2:53 A. M. one started heaving in again, and at 5:06 the trawl was at the surface, giving a towing time of about 10 hours in a depth of 1050–1100 meters and a total towing time of about 13 hours including hoisting and lowering.

As the following list will show, this single haul yielded a total of 47 different species of deepsea fish represented by 491 specimens, of which there were 118 specimens of species other than those of the genus *Cyclothone*. For comparison may be mentioned that 39 species was the highest number obtained by the "Pawnee" in 1927 in any one of 18 successful deepsea hauls in Bahaman and Bermudan waters with a ringnet of 14 feet diameter at the opening. If we carry the comparison further, we find an even more striking difference between the number of *large* specimens obtained in the triangular trawl at Station 1478 and the average number of large specimens in the above-mentioned 18 successful² hauls with a fourteen-foot ringnet.

¹ 1750 meters wire at 52° angle.

² Only the 18 hauls yielding a reasonable result to indicate successful operating

Since the size which constitutes a large specimen of course varies from one systematic group to another, it is naturally also necessary to adopt a variable set of arbitrary standards for the definition of the term large. Thus Iniomi have been considered large when they exceed 100 mm. length without caudal fin, but Apodes and Lyoneri only when they exceed 300 mm. Applying a variable set of standards of this sort in the same manner to both collections, we find the haul from Atlantis Station 1478 containing no less than 22 large specimens while the 18 hauls of the Pawnee give us an average of only 6.78 large specimens each, even when we consider the fact that the average towing time for these 18 hauls was only about half the towing time at Atlantis Station 1478 and accordingly divide the total for the Pawnee trawlings with 9 only, instead of 18. Thus there can hardly be any doubt about the superiority of the large triangular trawl for the capture of the larger specimens and species. If, on the other hand, we compare the total number of specimens of all species, with due consideration of trawling time, the situation is the reverse; which has to do with the fact that the smallest species are the numerically most abundant, and that proportionally fewer of these small individuals will be retained by the larger and of necessity also coarser net. The function of the large triangular trawl can therefore never be to replace entirely the large circular nets now in use but to supplement them for the capture of those larger forms which are too rarely obtained in the smaller gears.

LIST OF SPECIES OBTAINED IN TRIANGULAR TRAWL AT ATLANTIS STATION 1478

ISOSPONDYLI

STOMIATOIDEA

- 1 *Bonapartia pedaliota* Goode and Bean.....See page 8.
- 5 *Gonostoma elongatum* Günther
- 2 *Gonostoma bathyphilum* Vaillant
- 3 *Cyclothone braueri* Jespersen and Tåning
- 112 *Cyclothone pallida* Brauer.....See page 12.
- 258 *Cyclothone microdon* Günther.....See page 12.
- 2 *Yarrella blackfordi* Goode and Bean
- 2 *Ichthyococcus ovatus* Cocco
- 1 *Argyropelecus hemigymnus* Cocco
- 8 *Sternoptyx diaphana* Hermann

conditions have been considered for this comparison, leaving a number of less productive trawlings out of consideration.

- 1 *Echiostoma ctenobarba ramifer* n. subsp. See page 17.
 1 *Photostomias guernei* Collet
 2 *Malacosteus niger* Ayres
 1 *Chauliodus sloanei* Schneider
 3 *Chauliodus danae* Regan and Trewavas

INIOMI

MYCTOPHOIDEA

- 1 *Myctophum reinhardti* Lütken
 1 *Myctophum laternatum* Garman
 8 *Lampanyctus warmingi* Lütken
 8 *Lampanyctus subpectoralis* Parr
 1 *Lampanyctus photothorax* Parr
 2 *Lampanyctus tåningi* Parr
 2 *Lampanyctus lineatus* Tåning
 4 *Lampanyctus cuprarius* Tåning
 2 *Lampanyctus* spp.
 1 *Diaphus dumerili* Bleeker
 1 *Diaphus* sp.
 2 *Omosudis lowei* Günther
 1 *Bathypterois nigrescens* n. sp. See page 19.
 1 *Cetomimus kerdops* n. sp. See page 25.

GIGANTUROIDEA

- 1 *Gigantura vorax* Regan

LYOMERI

- 4 *Eurypharynx pelecanoïdes* Vaillant

APODES

- 1 *Derichthys serpentinus* Gill. See page 32.
 1 *Serrivomer sector longidentatus* Roule and Bertin
 1 *Labichthys carinatus* Gill and Ryder

ANACANTHINI

- 3 *Laemonema barbatula* Goode and Bean?

BERYCOMORPHI

- 1 *Gibberichthys pumilus* Parr. See page 36.
 5 *Melamphaes microps* Günther
 16 *Melamphaes opisthopterus* Parr
 1 *Melamphaes mizolepis* Günther

PERCOMORPHI

PERCOIDEA

- 1 *Dysalotus alcocki* McGilchrist

SCOMBROIDEA

- 2 *Decapterus macarellus* Cuvier and Valenciennes

OPHIDIOIDEA

- 1 *Brotulotaenia crassa* n. sp. See page 36.

PEDICULATI

CERATIOIDEA

- 6 *Melanocetus murrayi* Günther

- 3 *Lophodolus acanthognathus* Regan

- 1 *Trematorhynchus phyllodon* n. sp. See page 40.

- 1 *Linophryne arborifera eupogon* Regan and Trewavas. See page 46.

- 1 *Linophryne coronata diphlegma* n. subsp. See page 54.

- 1 *Amacrodon binghami* Parr 1927

- 2 *Borophryne masculina* n. sp. See page 56.

LIST OF NEW SUBFAMILY, GENERA, SPECIES, AND SUBSPECIES DESCRIBED IN THIS REPORT

Echiostoma calliobarba n. sp.

Echiostoma ctenobarba ramifer n. subsp.

Bathypterois nigrescens n. sp.

Ditropichthyinae n. subfam. (Cetomimidae)

Ditropichthys n. gen.

Cetomimus kerdops n. sp.

Gyrinomimus n. gen.

Gyrinomimus myersi n. sp.

Brotulotaenia crassa n. sp.

Trematorhynchus phyllodon n. sp.

Linophryne coronata diphlegma n. subsp.

Borophryne masculina n. sp.

LIST OF OTHER SPECIES AND SYSTEMATIC GROUPS, OR OTHER SUBJECTS SPECIALLY DISCUSSED IN THIS REPORT

Bonapartia pedaliota and genus *Bonapartia* ("Zaphotias"); discussion of synonymies.

GENUS *Cyclothone*; discussion of western Atlantic representatives with figures of *C. microdon* and *C. pallida*.

GENUS *Echiostoma*; key to species, *E. ctenobarba* redescribed with new species and subspecies.

SUBGENUS *Hemipterois* (genus *Bathypterois*); key to species.

FAMILY CETOMIMIDAE; complete revision, new genera; genera *Cetomimus* and *Cetostomus* redefined; figures.

Derichthys iselini Borodin = *D. serpentinus* Gill; figures and description of head. GENUS *Gibberichthys* and *G. pumilus* Parr; large specimen described and figured; with addenda to generic definition.

GENUS *Trematorhynchus*; remarks on classification.

GENUS *Linophryne*; synoptic re-arrangement of species (key).

Linophryne arborifera eupogon; detailed description and figure of barbel in type; comparison with new specimen and with *L. arborifera arborifera*.

Linophryne coronata coronata Parr; redescribed and figured.

Linophryne coronata longibarbata Borodin; described and figured.

Borophryne masculina; a new male species of Ceratioidea referred directly to its female genus.

SYSTEMATIC ANNOTATIONS

GENUS *BONAPARTIA* Goode and Bean

Bonapartia Goode and Bean: Oceanic Ichthyology, 1895, p. 102; Norman: Discovery Rept. Vol. II, 1930, p. 280.

Zaphotias Goode and Bean in: Jordan and Evermann, Fishes of North and Middle America, Vol. III, 1898, p. 2826.

As shown by Norman (loc. cit.) the name *Bonapartia* (Pisces) Goode and Bean antedates *Bonapartia* (Aves) Büttikofer, and is therefore the proper designation for the genus here considered, contrary to customary usage.

Bonapartia pedaliota Goode and Bean

Bonapartia pedaliota Goode and Bean 1895: Oceanic Ichthyology, p. 102, fig. 120; Jordan and Evermann 1896: Fishes of North and Middle America Vol. I, p. 580; Jespersen and Taaning 1919: Vidensk. Medd. Dansk Naturhist. Foren. Vol. 70, p. 221, pl. XVII, figs. 7-8; Norman 1930: Discovery Rep. Vol. II, p. 280, fig. 6.

Zaphotias pedaliota Jordan and Evermann 1898: Fishes of North and Middle America, Vol. III, p. 2826.

Zaphotias nudum Borodin 1930: Proc. New England Zool. Club (Boston), Vol. XI, p. 88; 1931: Bull. Mus. Comp. Zool. Vol. 72, No. 3, p. 71, pl. 2, fig. 2.

? *Zaphotias photocephalus* Roule and Angel 1933: Result. Camp. Sci. Monaco Fasc. LXXXVI, p. 25, pl. I, fig. 13 and 13a.

Due largely to the very misleading original illustration of *B. pedaliota*, considerable confusion and uncertainty has arisen in regard to the accurate definition of this species. To help clarifying the matter, the author has personally examined the type of Borodin's *B.* ("*Zaphotias*") *nudum*, and Dr. G. S. Myers of the U. S. National Museum has very kindly undertaken to make a comparison between the type of *B. pediolata* and the current concept of that species as

represented by a tracing of Norman's figure (Discovery Rept. Vol. II, fig. 6, p. 280).

According to Dr. Myers (*in. lit.*), the type is in complete agreement with Norman's figure both in regard to the spacing and arrangement of the photophores, in the presence of three subcaudal organs, in the form of maxillary and head, and in the forking of the caudal (subtruncate in Goode and Bean's figure). Dr. Myers also makes the observation that "there is no indication of the upper caudal photophore figured by Goode and Bean, even though the fish is uninjured in that region." It is thus evident that the current concept of the species held by such authors as Jespersen and Taaning, Norman, *et al.*, is entirely correct in its interpretation of the form described by Goode and Bean.

The distinction of *B. ("Zaphotias") nudum* (Borodin) as a separate species is chiefly based upon the proclaimed nakedness of the type. The author has been quite unable to verify this claim, finding, on the contrary, that although the scales have all become lost and the delicate skin is rather shrunken in alcohol, the remnants of the large scale pockets are still very evident under a microscope. There is thus at the present time no reason for accepting *B. nudum* as a valid and distinct species, but it might be pointed out that Borodin's type specimen has only two photophorees in the caudal group and only fourteen on each side in advance of the ventral fins in accordance with what has been described by Jespersen and Taaning as typical of *B. pedaliota* and what is also found in the present specimen. In the type of *B. pedaliota* and in the specimen recorded by Norman (*loc. cit.*) the caudal group has 3 photophores and Norman gives a count of 16 photophores between gill openings and ventral fins. In the author's opinion this is probably only a matter of individual variation, but if subsequent investigations should give taxonomic significance to the presence of two or of three photophores in the caudal group, Borodin's name would be available for the form in which only 2 organs are found in this position, Goode and Bean's designation referring to the other.

B. ("Zaphotias") photocephalus (Roule and Angel) is also described as naked and special emphasis is laid upon the presence of 3 photophores on the head, one suborbital, one "opercular" (on the upper part of the gill cover), and one at the corner of the preopercle. These 3 photophores, however, are also present in the types of *B. pedaliota* Goode and Bean (Myers *in lit.*) and of *B. ("Zaphotias") nudum* (Borodin) [Borodin's statement to the contrary (Borodin 1930, *loc. cit.* p. 89) notwithstanding], and in the specimen on hand. They are also all clearly shown in Jespersen and Taaning's figure 7 (*loc. cit.*) and the suborbital and opercular ones are figured by Norman (*loc. cit.*, fig. 6). The photophores on the head are thus not distinctive of *B. photocephalus*, and in view of the highly deciduous character of the scales and the ease with which even the scale pockets may become abraded from the extremely delicate skin, the author feels fairly convinced that *B. photocephalus* should also be listed among the synonyms of *B. pedaliota*.

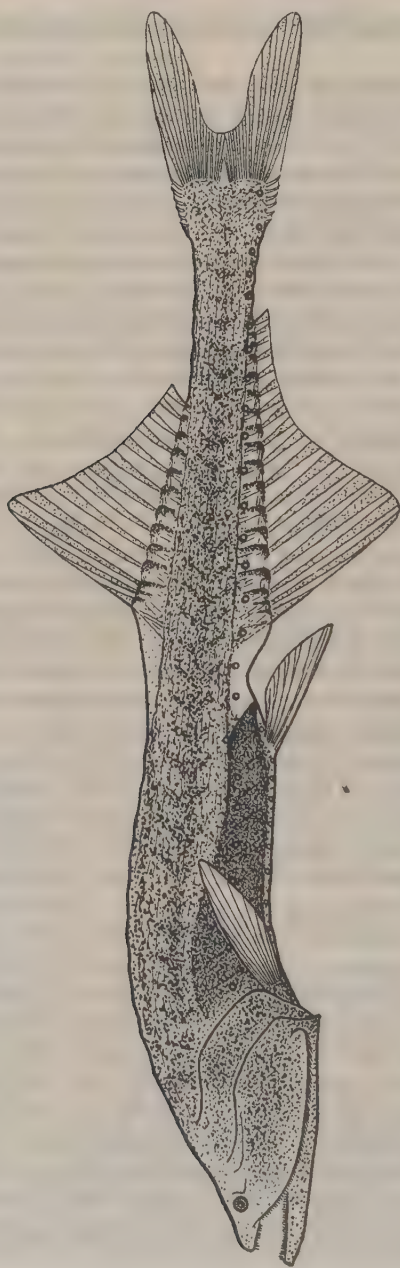


Figure 2. *Cyclothone pallida* Brauer. Drawn by author.

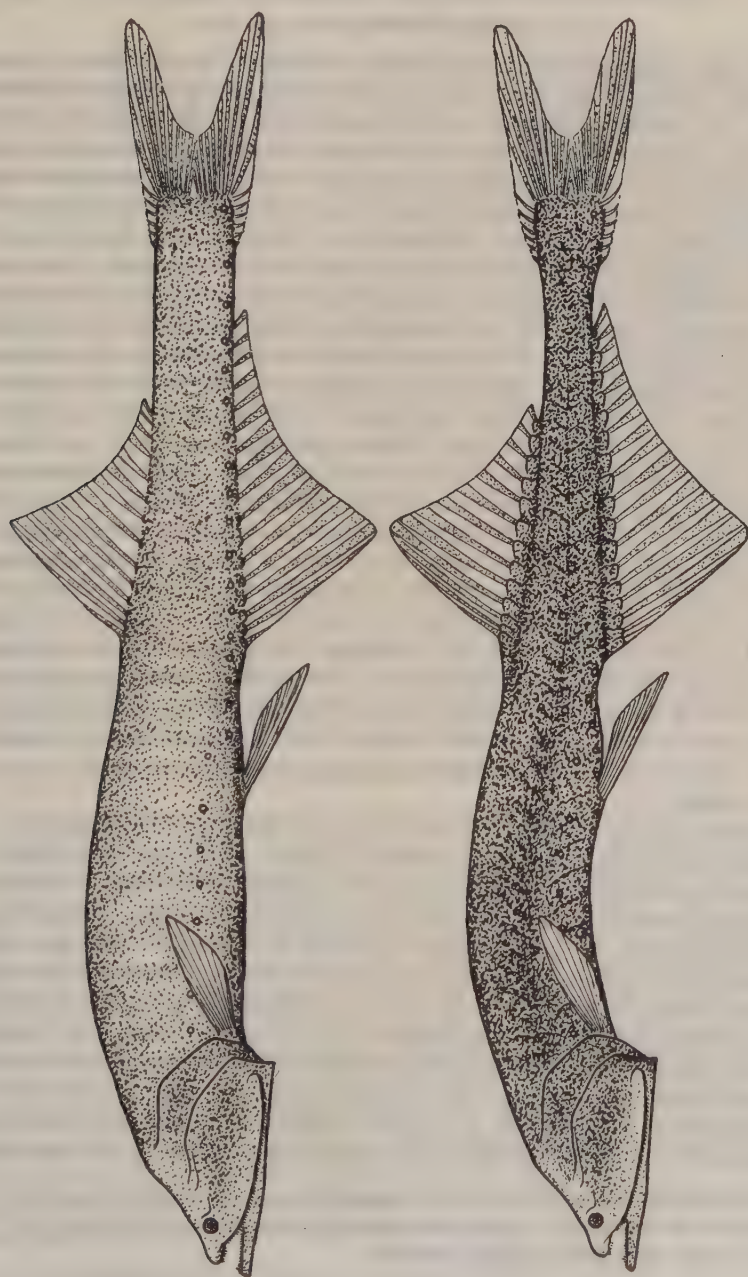


Figure 3. *Cyclothone microdon* Günther. Well nourished (fat) specimen above, emaciated specimen below. Drawn by author.

GENUS **CYCLOTHONE** Goode and Bean

Through examination of a great number of samples from the eastern central Atlantic, the author has come to the conclusion that the *Cyclothone* populations of this area consist of 3 species only, the pale *C. braueri*, the brown *C. pallida*, and the brown to black *C. microdon*. Of these *C. braueri* is already so well established and so easily distinguished from the other two that no further comments are required. In formalin preservation and in the fresh material, *C. pallida* is also so conspicuously different from *C. microdon* that the two can be easily separated even by the most casual inspection of a sample. The most striking features of *C. pallida* as compared with *C. microdon* are contributed by the completely pigment-free and transparent ventral area of the skin between its ventral and its anal fin, in the anterior portion of which the black peritoneum lining the tapering end of the abdominal cavity is visible; by the development of internal pigmentation at each pterygiophore in its dorsal and anal fins in alternation with transparent areas between pterygiophores; and to a lesser extent by its generally paler and more transparent skin, with the peritoneum showing through quite clearly in the entire abdominal region and a transparent triangular area generally noticeable in front of the dorsal fin where no opaque tissues are present. In the accompanying figure 2 the author has attempted to show these features as they appear in formalin specimens.³ Although *C. pallida* has been illustrated twice before (Brauer 1906, Wiss. Ergeb. "Valdivia," Vol. XV, Tiefsee-Fische, pl. VI, fig. 2; Zugmayer 1911, Res. Camp. Sci. Monaco, Fasc. XXXV, pl. II, fig. 2), neither of the previous illustrations give any clear impression of the appearance of the preserved material with which most investigators have to work. In the author's opinion the differences between *C. pallida* and *C. microdon* are such that there is no reason for treating one as a subspecies of the other.

In regard to the material here recorded as *C. microdon*, the author was at first in considerable doubt as to whether it might not include more than one species, the uncertainty being caused by the extremely wide range of variations in general appearance observed among the specimens. It has not been found possible, however, to correlate these variations in appearance with any other feature than the absence or presence and degree of development of the subdermal adipose tissues which appear to be a characteristic of well-nourished specimens of *C. microdon*, but has not been observed at all (macroscopically) in *C. pallida*. This adipose tissue develops particularly along the bases of the dorsal and anal fins and in the median above and below the caudal peduncle, thereby altering the outlines of the peduncle in a most conspicuous manner and completely effacing the sculptural character of the entire tail as shown in the emaciated

³ In specimens preserved in alcohol, especially if any shrinkage has occurred, the distinctive characters of *C. pallida* are somewhat less striking to the eye, but are usually easily revealed by closer inspection.

specimens (see figure 3). A great development of adipose tissues is also found on the flanks and back of the trunk and also, in a lesser degree, along the sides of the tail; the entire result being a smooth, well-rounded specimen of an oval cross-section as compared with the almost ribbon-like bodies of the emaciated specimens in which all the details of the muscular anatomy are evident on the surface. In formalin specimens the adipose tissues appear as a dense agglomeration of rather large oil globules, wherever the skin is torn to make it visible. In alcohol material the oil has usually been completely extracted and the adipose tissue is shrunken and collapsed. Alcohol material will therefore not show the same range of variation in general shape as formalin specimens or fresh samples, but it seems indicated that an emaciation of the musculature in life occurs parallel with the exhaustion of the adipose tissues so that a specimen which was fat in life will seem relatively corpulent also after the oil has been artificially extracted in alcohol preservation, although it will always lose its smoothness of surface. It also seems evident that emaciation in life is often continued long beyond the complete exhaustion of all adipose tissues so that varying degrees of emaciation is also to be observed among specimens in which no oil at all is left. Since counts and measurements have failed to show any features distinguishing the emaciated from the fat specimens, the author feels confident in referring them all to the same species, with the suggestion that the ability to develop the above described adipose tissues may perhaps in itself be considered a specific character of *C. microdon* although it can only be used for the identification of the specimens in which it has found a morphological expression, i. e. in the well nourished individuals.

GENUS **ECHIOSTOMA** Lowe 1843

In their revision of the genus *Echiostoma* Regan and Trewavas (1930, Danish "Dana" Exp. 1920-22. Oceanogr. Rep. No. 6 p. 116) recognize 4 separate species, basing their differentiation upon variations in the bulbs and appendages of the barbel and in the size of the postocular luminous organ. In addition to the specimen caught in the haul here reported upon, two other large representatives of the genus *Echiostoma* are now available in the Bingham Oceanographic Collection, one being the type of *E. ctenobarba* Parr, the other the type of a new species collected by the Atlantis at station 1030.⁴ Since each of the three specimens shows considerable differences from the others in the structure and appendages of their barbels, and since the better facilities now available to the author also make a more detailed description and illustration of the barbel of *E. ctenobarba* possible at this time, a brief account will be given in this connection of each of the 3 forms represented by these three specimens. The clearest impression of the mutual relationships of these various species and subspecies may perhaps be obtained from the following key.

⁴ The collection also contains three small specimens of *E. tanneri* Gill, which need not be considered in this connection.

- I. Barbel with two white bulbs, a longer proximal and a shorter distal one at the end of its main stem, both wider than the stem and sharply differentiated also externally. Distal bulb with terminal filaments.
E. tanneri Gill 1883
- II. Barbel with not more than one externally differentiated main bulb, or without. Not as above. With or without additional internal bulb or bulbs.
 - A. Barbel with simple terminal appendage.
 1. "Barbel with bulb not thicker than stem, bearing a simple flat terminal appendage; filaments on stem rather short. Postocular luminous organ $1/5$ length of head (in a specimen of 285 mm.)."⁵
E. barbatum Lowe 1843
 2. "Barbel with distinct bulb and simple slender terminal appendage; filaments on stem long. Postocular organ $1/4$ length of head (in a specimen of 215 mm.)."⁵
E. guentheri Regan and Trewavas 1930
 - B. Barbel with branched terminal filament.
 1. Lateral filaments on stem of barbel small and delicate, each with a minute globular white bulb at its distal end. End of stem marked by a round internal, white body (luminous bulb) beyond which the barbel is continued as a thick, tapering terminal filament which bifurcates twice to form 4 equivalent branches with minor branches distally and a pair of small lateral filaments at the first bifurcation. Length of postocular luminous organ 5 in length of head. (In specimen 290 mm. long).
E. calliobarba n. sp.
 2. Lateral filaments on stem of barbel coarser, without terminal bulbs. Length of postocular luminous organ $3\frac{1}{2}$ to $3\frac{3}{5}$ in length of head. (In specimens 275-297 mm. long).
E. ctenobarba Parr 1927
 - a. Lateral filaments on the main stem of the barbel relatively short and blunt, their series occupying only about $2/5$ of the distance from the base of the last (distal) filament to the base of the barbel. Main stem of barbel without visible internal bulb at the distal end.
E. ctenobarba ctenobarba Parr
 - b. Lateral filaments on the main stem of the barbel long and pointed, their series occupying nearly $1/2$ of the distance from the base of the last filament to the base of the barbel. Main stem of barbel with a conspicuous, round, whitish body (luminous bulb ?) internally on the ventral (anterior) side near its distal end. . . . *E. ctenobarba ramifera* n. subsp.

⁵ Regan and Trewavas 1930, *loc. cit.* p. 116.

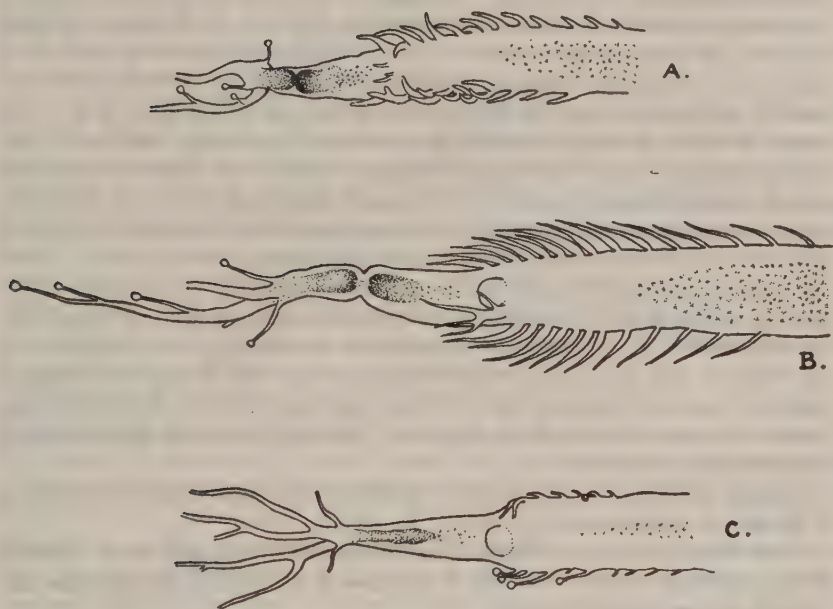


Figure 4. Barbels of *Echiostoma*: A. *Echiostoma ctenobarba ctenobarba* Parr. B. *Echiostoma ctenobarba ramifera* n. subsp. C. *Echiostoma calliobarba* n. sp. Drawings by author.

***Echiostoma calliobarba* n. sp.**

Length without caudal fin 290 mm. Proportions in percent of length without caudal fin: Length of head 15.5. Snout 3.8. Interorbital width 5.52. Diameter of eye 2.20. Lower jaw 13.3. Length of postocular luminous organ⁶ 3.03. Greatest depth of body 12.9. Snout to ventrals 57. Origin of dorsal to base of middle caudal rays 17.5. Origin of anal to middle caudal rays 17.0. End of dorsal fin base to middle caudal rays 8.0. End of anal fin base to middle caudal rays 5.5. Length of pectoral filament 40.3. Length of lower pectoral rays 7.9. Length of ventrals 16.7. Distance from base of barbel to distal end of its internal bulb 5.9. Distance occupied by lateral series of filaments on barbel 1.7.

Lateral series of photophores: O-V 25. V-A 17. A-C 11. Ventral series:

I-P 8 + 2. P-V 26. V-A 17.

D 12½. A 16½. V 8. P 1 + 3.

⁶ See footnote 9 page 17.

Lateral filaments on the stem of the barbel thin and delicate, each⁷ ending in a globular, whitish bulb. About 9 filaments on each side, their series occupying less than 1/3 of the distance from the base of the distal filament to the base of the barbel. A round, whitish, ventrally-situated, internal body (luminous bulb ?), conspicuous from the exterior, marks the end of the main stem of the barbel, which is continued distally by a terminal appendage, the darkly pigmented internal core of which does not appear to have any definite constriction as in *E. ctenobarba* at any point. The terminal appendage bifurcates once, each branch branching again at least once, so that at least 4 main branches are formed, apart from possibly bulb-bearing filaments arising from various parts. There are a pair of opposed filaments at the point of bifurcation of the terminal appendage similar to the filaments found at its first branching point in *E. ctenobarba*. The filaments in *E. calliobarba* are incomplete, however, and it is impossible to say whether they have been bulb-bearing or not. Two of the four ultimate branches have one remanent each of what may have been a small secondary branch or merely a bulb-bearing filament. The main branches themselves are all incomplete at the tip.

Entirely similar to the other species of *Echiostoma*, particularly *E. ctenobarba* in its general appearance.

Type No. 3201 of the Bingham Oceanographic Collection from Atlantis Station 1030; 37° 47' N. 31° 41' W., August 4-5, 1931; 15 foot circular net, 610-930 meters vertical depth.

***Echiostoma ctenobarba ctenobarba* Parr 1927**

Echiostoma ctenobarba Parr 1927, Bull. Bingham Oceanogr. Coll. Vol. III, Art. 3, p. 55, figs. 32 and 33; Regan and Trewavas, 1930, Danish "Dana" Exp. 1920-22, Oceanogr. Rep. No. 6, p. 116, fig. 112c.

The introduction of a new subspecies of the same species and the better facilities for a detailed examination of a specimen of this size now available to the author makes a redescription of the type specimen seem desirable at this point.

Length without caudal fin 275 mm. Proportions in per cent of length without caudal fin: Length of head 15.6. Snout 3.8. Interorbital width 5.20. Diameter of eye 2.40. Lower jaw 12.2. Length of postocular luminous organ⁸ 4.60. Greatest depth of body 15.6. Snout to ventrals 58.7. Origin of dorsal to base of middle caudal rays 17.8. Origin of anal to middle caudal rays 16.5. End of dorsal fin base to base of middle caudal rays 7.6. End of anal fin base to middle caudal rays 5.3. Length of pectoral filament > 35.0. Length of lower pectoral rays 6.6. Length of ventrals 14.5. Distance from base of barbel to base of its ultimate lateral filament 5.1. Distance occupied by lateral series of filaments on barbel 2.2.

⁷ i. e., all of the filaments which have been preserved intact in the type specimen.

⁸ See footnote 9.

Lateral series of photophores: O-V 25. V-A 16. A-C 12. Ventral series: I-P 8 + 2. P-V 26. V-A 17, only the last organ above the base of anal fin.

D $12\frac{1}{2}$. A $15\frac{1}{2}$. V 8. P 1 + 3.

Lateral filaments on stem of barbel relatively short and blunt, finger-like, without terminal bulbs, their series occupying only about $\frac{2}{5}$ of the distance from the base of the distal filament to the base of the barbel. The lateral filaments are arranged in a regular, single series on one side, while the series on the other side is more irregular with the insertions of some of the filaments diverging from the straight line through the rest of the series. The penultimate filament on the side of the irregular series has a stubby branch, and there are three minute, simple filaments inserted in the middle of the ventral (anterior) surface of the barbel between its ultimate lateral filaments. About 13-15 filaments on each side of the barbel. There are no signs of an internal bulb visible from the exterior at the end of the main stem of the barbel.

The terminal appendage continuing the barbel beyond the lateral series of filaments has a darkly pigmented internal core which shows a sharp constriction at a distance in advance of the first branch but a less well marked separation of the parts than in *E. ctenobarba ramifer* (compare fig. 4A and B). The constriction hardly affects the exterior of the terminal appendage at all. The terminal appendage branches once, both branches being partly mutilated in the type, but apparently similar to those in *E. ctenobarba ramifer*, with a pair of opposed, bulb-bearing filaments at their branching point and a couple or more of similar bulb-bearing filaments on one of the branches, at least.

***Echiostoma ctenobarba ramifer* n. subsp.**

Length without caudal fin 297 mm. Proportions in per cent of length without caudal fin: Length of head 14.3. Snout 3.4. Interorbital width 5.0. Diameter of eye 2.25. Lower jaw 12.0. Length of postocular luminous organ⁹ 4.3. Greatest depth of body 12.8. Snout to ventrals 57.0. Origin of dorsal to base of middle caudal rays 16.5. Origin of anal to middle caudal rays 16.5. End of dorsal fin base to middle caudal rays 7.5. End of anal fin base to middle caudal rays 4.9. Length of pectoral filament 42.5. Length of lower pectoral rays 6.3. Length of ventrals 12.0. Distance from base of barbel to distal end of its internal bulb 6.4. Distance occupied by lateral series of filaments on barbel 3.0.

Lateral series of photophores: O-V 26. V-A 16. A-C 12. Ventral series: I-P 8 + 2. P-V 27. V-A 17, only the last organ above the base of anal fin.

D 13. A $16\frac{1}{2}$. V 8. P 1 + 3.

Lateral filaments on the stem of the barbel relatively long and pointed, somewhat compressed, particularly the more distal ones; without terminal bulbs; in a single series on each side occupying nearly half of the distance from the base

⁹ Measured as the length of the transparent area of the skin covering the luminous parts.

of the distal filament to the base of the barbel. About 13-15 filaments on each side. A round, whitish, very conspicuous internal body (luminous bulb ?) situated ventrally between the last lateral filaments marks the end of the stem of the barbel as here understood. The last lateral filament on one side encroaches upon the ventral (anterior) surface of the barbel beside the internal bulb and carries two branches, the distal one of which is again bifurcated, so that four filaments in all, including the terminal one, arise from the stem of this appendage (see figure 4B).

The terminal appendage continuing the barbel beyond the internal bulb has an inner darkly pigmented core which is sharply subdivided by a constriction about halfway between the internal bulb and the base of the first branch. This constriction is well marked also externally. Beyond the constriction the terminal appendage branches once, but due to mutilation of one of them it is impossible to tell whether the branches have been equivalent or not. The un mutilated branch carries three thin lateral filaments, one incomplete, and the other two ending in a small, globular, whitish bulb each. The branch itself terminates in a similar but slightly larger bulb and there is an opposed pair of similar bulb-bearing filaments at the branching point of the terminal appendage.

General appearances in the other species of *Echrostoma*.

Type of the subspecies No. 3202 of the Bingham Oceanographic Collection Atlantis Station 1478.

GENUS **BATHYPTEROIS** Günther

SUBGENUS **HEMIPTEROIS** Regan

Hemipterois Regan 1911: Ann. Mag. Nat. Hist. Ser. 8, Vol. VII, pp. 126 and 127. Parr 1928: Bull. Bingham Oceanogr. Vol. III, Art. 3, p. 25.

Belonepterois Roule 1916: Bull. Inst. Oceanogr. Monaco No. 320, p. 13; 1919: Res. Camp. Sci. Monaco Fasc. LII, p. 35.

As subgenus *Hemipterois* is here considered the species with 6 or more rays in the upper portion of the pectoral fins, without a notch in the ventral outline at the base of the lower caudal rays, and with the outer ventral and lower caudal rays always, and the upper pectoral rays sometimes, strongly produced. As opposed to these forms, the species with only four or less rays in the upper portion of the pectoral fins are arranged in the subgenus *Bathypterois* (see Parr 1928, loc. cit.).

The specimen collected at Atlantis station 1478 adds a third species of subgenus *Hemipterois* to the two previously known. These species may be distinguished as follows:

Key to subgenus *Hemipterois*

1. Longest (upper) pectoral ray rigid and enormously produced reaching to or beyond the end of caudal fin. Only 5 rays in lower portion of pectoral fin.

Dorsal origin a little in advance of the middle of the body, anal origin immediately behind the end of the dorsal fin base.

Bathypterois (Hemipterois) guentheri Alcock

2. Longest rays in upper portion of pectorals not reaching to the adipose dorsal fin. Origin of anal fin approximately below middle of dorsal fin base.

A. Dorsal origin a little in advance of the middle of the body.¹⁰ Only 5 rays in the lower portion of pectoral fin. Color light gray.¹¹

Bathypterois (Hemipterois) viridensis Roule

- B. Dorsal origin immediately behind the middle of body. 6 rays in lower portion of pectoral fin. Color black (see description).

Bathypterois (Hemipterois) nigrescens n. sp.

***Bathypterois (Hemipterois) nigrescens* n. sp.**

Length without caudal fin 61 mm. Proportions in per cent of length without caudal fin: Snout to dorsal fin 51.6. Length of head 27.4. Snout to eyes 8.7. Interorbital space 8.0. Maxillary 16.7. Length of dorsal fin base 14.7. Snout to anal fin 59.0. Longest caudal ray 59.0. Longest ventral ray 69.7. Longest pectoral ray (upper portion) 23.0. Snout to ventral fins 43.8. Greatest depth of body (deflated) 18. Least depth of caudal peduncle 8.9.

D. 12. A. 11. V. 8. P. (1-2 + 7) + (6). L1. 50.

In general appearance the type of *B. nigrescens* seems slightly shorter and somewhat chunkier than a specimen of *B. viridensis* of comparable size. This effect is partly due, however, to a liquid inflation between skin and musculature which makes it difficult to determine the natural proportions of *B. nigrescens* in regard to body-width and depth, but it seems indicated that the apparent relative stubbiness of this form is at least in part natural to the species. There are otherwise no features in the general appearance of *B. nigrescens* to distinguish it from the other known species of the same genus.

The upper portions of the pectoral fins each consist of 7 rays, plus two rudimentary rays closely applied to the upper and longest normal ray. The rays in the upper portion of the fin are united by fin membrane and are much more closely set than are the rays in the lower portion. The lower portions of the pectorals each contain 6 about equally spaced free rays, of which the lowest is the longest but unfortunately incomplete on both sides. In *B. viridensis* the interspace between the two portions of the pectorals is greatly increased as compared with the interspaces between the rays in the lower portion itself. In *B. nigrescens* this interspace is divided by the 6th lower ray so that the spacing of the lower portion continues to the first ray in the upper.

The produced ray in each ventral fin splits in two approximately opposite the base of caudal, beyond which they extend for an unknown distance, their

¹⁰ Snout to dorsal fin 47.7-48.5 per cent of length without caudal.

¹¹ Observed by the author on the newly caught specimen.

ultimate portions apparently being lost. Both of the two produced lower caudal rays also divide distally, but it is questionable whether the division of the produced rays in this specimen may not be accidental in all cases.

The skin has apparently been subject to considerable rubbing in the net, but wherever the pigmentation is preserved, whether on back, sides, abdomen, or tail, it indicates a uniform black coloration, in contrast with the light peppered gray of *B. viridensis*. The caudal fin is also black, the other fins pale.

Type No. 3203 of the Bingham Oceanographic Collection Atlantis station 1478.

FAMILY CETOMIMIDAE

From a comparison of the new cetomimid specimen obtained by the "Atlantis" at station 1478 with the other examples of this family already available in the Bingham Oceanographic Collection, it immediately became apparent, on the basis of external appearances alone, that at least two entirely distinct generic types were present in the material. Further examination also soon divulged the existence of a third taxonomic type, represented by the so-called *Cetomimus storeri*, which appears to stand so far apart from the other cetomimid forms that at least a separate subfamily is required for its classification. A revision of the entire family thus became necessary and in this effort the author has been greatly aided by the information concerning the type of *Cetomimus gilli* kindly supplied by Dr. G. S. Myers of the U. S. National Museum on the basis of a comparison with the type of *Gyrinomimus myersi* n. gen. et n. sp.

With the sharpened generic definitions, it also seems appropriate to resurrect the genus *Cetostomus* Zugmayer which the writer has previously synonymized with *Cetomimus* Goode and Bean, with which it is closely related.

Key to the CETOMIMIDAE¹²

I. Gills 4, a moderate slit behind the fourth. Gill rakers present.

Subfamily DITROPICHTHYINAE

A pair of thin dermal folds along the entire ventral edge of the abdomen, continued posteriorly as a free, curtain-like, skin fold on each side of the

¹² The genus *Pelecinomimus* Gilchrist (Rep. Fish. Mar. Biol. Surv. Union of S. Africa, Vol. II, p. 56) is described as having "very long scales," but these scales are not shown in the figure of the type-species, which, on the contrary, seems to suggest a typical naked cetomimid form, as already pointed out by Barnard (Ann. S. African Mus. Vol. XXI, Pt. 1, 1925, p. 252). If scales are actually present, the genus would occupy an entirely separate position, if not, it might very likely prove to be only a synonym for *Cetomimus* Goode and Bean. As it stands at present, there is too great uncertainty attached to its definition to make it possible to include it in the above key or to deal further with it in the text.

anal fin base. Teeth small, villiform, in irregular bands in jaws, vomer, and palatines. Gill rakers thick, club-shaped; present on all arches.

Genus *Ditropichthys* n. gen.

Ditropichthys storeri Goode and Bean

II. Gills 3, a small slit behind the third. Gill rakers absent.

Subfamily CETOMIMINAE

A. Teeth minute, short and broad ("granular") in irregular bands in the jaws, on vomer, palatines, pterygoids, gill arches and tongue, without forming a specially differentiated oval shield on the latter. Head not tadpole-like.

1. Dorsal and anal fins moderate (D 20 or less, A 17 or less). Trunk relatively robust.

Genus *Cetomimus* Goode and Bean

- a. Head not much compressed, less than 3 times in the length without caudal. Distance from origin of dorsal fin to end of hypural about 4, greatest external width between rami of lower jaw about 7 in length without caudal.

C. gilli Goode and Bean

- b. Head compressed, more than 3 times in the length without caudal. Distance from origin of dorsal fin to end of hypural about 3 1/4, greatest external width between rami of lower jaw nearly 12 in length without caudal.

C. kerdops n. sp. ad. int.

2. Dorsal and anal fins long (D about 30, A about 27). Trunk very attenuate. Tail at D and A high and compressed. Head compressed.

Genus *Cetostomus* Zugmayer

Cetostomus regani Zugmayer

B. Teeth very small, but slender and elongate, arranged in a number (3-5) of very close-set and extremely precise series in the jaws. Similar teeth on vomer, palatines, and pterygoids. An oval shield of concentrically-arranged curved teeth on the tongue. Slightly elongate teeth in gill arches. Head broad, depressed, tadpole-like.

Genus *Gyrinomimus* n. gen.

Gyrinomimus myersi n. sp.

DITROPICHTHYS NEW GENUS

Gills 4, a small opening behind the fourth. Thick, club-shaped, denticulate gill rakers present on all of the four free arches. Eyes small but not rudimentary. Head and body compressed, naked. Lateral line very wide, prominent, semi-tubular, with few, enormous pores. Pectorals low. Dorsal and anal fins high,

with about 20 or less rays of fairly uniform length giving the fins a rectangular rather than triangular outline. A deep, free skin fold with a lobate edge (see figure) extends along each side of the base of anal fin, while a pair of simple-edged dermal folds occupy the ventral distance from anal opening to shoulder girdle. Mouth very large. Teeth small, in villiform bands on jaws, vomer, palatines, pterygoids and in a short patch on the tongue. Lateral line pores on trunk and tail few (about 12), large and simple, without flaps.

Genotype: *Ditropichthys storeri* (Goode and Bean).

At the end of their description of *Cetomimus storeri*, Goode and Bean (1895, *Oceanic Ichthyology*, p. 69) make the statement that the type of the species was no longer available at the time when they made their studies of the cetomimid fishes in preparation of their report, their account of *C. storeri* being based solely upon a drawing previously prepared under the supervision of Dr. Bean. From this it is evident that the generic definition of *Cetomimus*, except in so far as the purely external features are concerned, must have been based upon *C. gilli* only, but this implication of Goode and Bean's statement has unfortunately been overlooked in the two subsequent new records and redescriptions of *C. storeri* published by Brauer (*Die Tiefsee Fische. I Syst. Teil. Wiss. Erg. Valdivia* Vol. 15, 1906, p. 252, pl. X, fig. 5), and by the present writer (Parr, *Bull. Bingham Oceanogr. Coll. Vol. III, Art. 3, 1928, p. 177, fig. 43*), and it has thus been left for the report in hand to introduce the discovery that "*Cetomimus*" *storeri*, far from being a congener of *Cetomimus gilli*, actually occupies a very isolated position in the family Cetomimidae in a separate genus and subfamily.

The above analysis of this genus and the following account of its only known species is based upon specimen No. 2134 of the Bingham Oceanographic Collection.

***Ditropichthys storeri* (Goode and Bean)**

Cetomimus storeri Goode and Bean: *Proc. U. S. Nat. Mus.*, Vol. 17, (1894) 1895, p. 453, pl. 17, fig. 3; *Oceanic Ichthyology*, 1896, p. 69, fig. 79; Jordan and Evermann: *Fishes of North and Middle America*, Vol. I, 1896, p. 550; Brauer: *Die Tiefsee Fische I Syst. Teil. Wiss. Erg. Valdivia*, Vol. 15, 1906, p. 252, pl. X, fig. 5; Parr: *Bull. Bingham Oceanogr. Coll. Vol. III, Art. 3, 1928, p. 177, fig. 43*).

Length without caudal fin (to end of hypural) 27 mm. Proportions in per cent of this measurement: Length of head 38.9. Length of snout 14.8. Diameter of eye 3.0. Length of maxillary 24.1. Length of lower jaw 25.9. Depth of head 29.6. Greatest width of skull 16.7. Interocular width 11.9. Height of dorsal dermal crest 6.6. Depth of supra-anal skin fold 2.2. Snout to dorsal fin 65.5. Base of dorsal fin 23.7. Base of anal fin 17.4. Distance from base of anal fin to end of hypural 15.2. Depth of caudal peduncle 6.0.

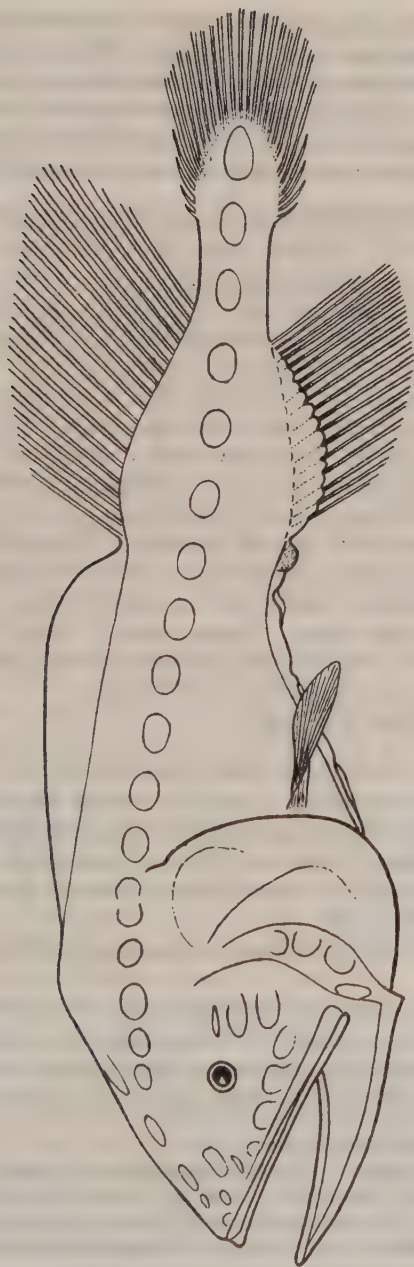


Figure 5. *Ditropichthys storeri* (Goode and Bean). Drawn by Y. H. Olsen.

D 19-20. A 16-18.¹³ Lateral line with 12 enormous pores between the shoulder and its posterior end on the caudal fin. There are 3 gill rakers in the upper portion, 1 at the angle, and 8 in the lower portion of the first arch. The supra-anal skin folds terminate at the base of the fourth or fifth anal ray counted from behind, their edges showing 13 lobate subdivisions each.

Known from the Atlantic and Indian Oceans (3 specimens).

GENUS **CETOMIMUS** Goode and Bean, *sensu stricto*

Cetomimus (partim) Goode and Bean: Proc. U. S. Nat. Mus. Vol. XVII, 1894 (1895), p. 452; Oceanic Ichthyology, 1895, p. 68; Jordan and Evermann, Fishes of North and Middle America, Vol. I, 1896, p. 549; Brauer, Die Tiefsee Fische. I. System. Teil. Wiss. Erg. Valdivia, Vol. XV, 1906, p. 251; Parr, Bull. Bingham Oceanogr. Col. Vol. III, Art. 3, 1928, p. 173.

Gills 3, a small opening behind the third. Gill rakers absent. Eyes minute. Head not tadpole-like, generally more or less compressed. Trunk and tail compressed. Mouth very large. Lower jaw with a prominent lateral bony protuberance behind the end of the upper jaws. Dorsal and anal fins with less than 20 rays each, the rays being graduated in length so as to give the fins a pointed, oblique, triangular outline.¹⁴ Caudal moderate. Pectorals short, low, but lateral. Teeth short, stubby, "granular"; in a band of 3-5 alternating rows in each jaw. Similar teeth in a short patch on vomer, in bands on palatines and pterygoids and on the gill arches. Lingual patch of teeth long, narrow, and irregular. Lateral line pores on head and body simple, about 20¹⁵ or more between the top of the gill slit and the end of the tail.

Genotype *C. gilli* Goode and Bean.

Cetomimus gilli Goode and Bean

Cetomimus gilli Goode and Bean. Proc. U. S. Nat. Mus. Vol. XVII, 1894 (1895), p. 452, pl. 17, fig. 2; Oceanic Ichthyology, 1895, p. 69, fig. 78; Jordan and Evermann, Fishes of North and Middle America, Vol. I, 1896, p. 549.

? *Cetomimus gilli* Brauer: Die Tiefsee-Fische. I. System. Teil. Wiss. Erg. Valdivia Vol. XV, 1906, p. 251.

Nec. *Cetomimus gilli* Parr: Bull. Bingham Oceanogr. Coll. Vol. III, Art. 3, 1928, p. 176.

From the measurements given by Brauer (loc. cit. p. 252). The Valdivia specimen would seem to agree with *C. kerdops* rather than with *C. gilli* in regard to the length of the head (31.3 per cent of body length; 36.4 per cent in the type of *C. gilli*)¹⁶ and the distance from origin of dorsal to base of caudal fin

¹³ Previous count erroneously too low.

¹⁴ Described from *C. kerdops*. Probably also applies to *C. gilli*.

¹⁵ 21 pores are vaguely indicated in Goode and Bean's figure of *C. gilli* (Oceanic Ichthyology, fig. 78, pl. xxi) and approximately 25 are counted in *C. kerdops*.

¹⁶ The author is indebted to Mr. George S. Myers of the U. S. National Museum for furnishing these measurements of the type of *C. gilli*.

(snout to origin of dorsal 67.7 per cent of body length, leaving 32.3 per cent as a minimum for the distance from origin of dorsal to base of caudal which measures 25 per cent in the type of *C. gilli*).¹⁷ The interorbital width of Brauer's specimen is, on the other hand, greater (14.6 per cent of body-length) even than that in the type of *C. gilli* (13.4 per cent of length without caudal¹⁸). It is therefore not unlikely that Brauer has actually been dealing with a third, independent species.

The characters differentiating *C. gilli* from *C. kerdops* are given in the key on page 21.

Cetomimus kerdops n. sp.

Length without caudal fin 47.5 mm. Proportions in per cent of this measurement. Length of head (snout to pectorals) 31.6. Length of maxillary 28.2. Length of lower jaw 31.0. Snout to eye 12.6. Interorbital width (= width of skull) 10.5. Greatest external width between rami of lower jaw 8.4. Snout to top of gill slit 24.9. Width between tops of gill slits 5.9. Length of pectorals 9.5. Snout to origin of dorsal fin 71.1. Base of dorsal fin 17.5. Base of anal fin 17.5. Snout to anal fin 72.2. Longest rays in dorsal and anal fins 15.8. Greatest depth 18.7. Greatest height between bases of dorsal and anal fin rays 12.6. Least depth of caudal peduncle 5.9. Diameter of eye about 2.0.

D. 16. A. 17. P. 19 (approx.). About 25 pores in the lateral line between top of gill slit and end of tail.

A mosaic band of three alternating rows of teeth in each jaw. Dentition on other parts as described in the generic definition.

Dorsal profile of snout slightly concave. Antero-lateral corners of skull (frontals ?) forming conspicuous prominences at the last third of the distance from the snout to the eyes which are situated laterally below the broadest part of the cranium. Mouth strongly oblique, lower jaw slightly prominent at the tip. A short, sturdy, downwardly-directed spine is formed by the angular at the posterior end of the lower jaw. Above this angular spine a spine-like lateral protuberance arises from the side of the lower jaw with a receiving concavity for the end of the upper jaws anteriorly. The body is somewhat arched with head pointing downwards, and its outlines smooth. Dorsal and anal fins with triangular profiles. Uniform black, fins included.

Type specimen No. 3204 of the Bingham Oceanographic Collection. Atlantis station 1478.

GENUS **CETOSTOMUS** Zugmayer

Cetostomus Zugmayer, Bull. Inst. Oceanogr. Monaco No. 288, 1914, p. 4.

Cetomimus (partim) Parr, Bull. Bingham Oceanogr. Coll. Vol. III, Art. 3, p. 173. Occas. Pap. Bingham Oceanogr. Coll. No. 2, 1929, p. 23.

¹⁷ Myers, *in lit.*

¹⁸ Cf. footnote on preceding page.

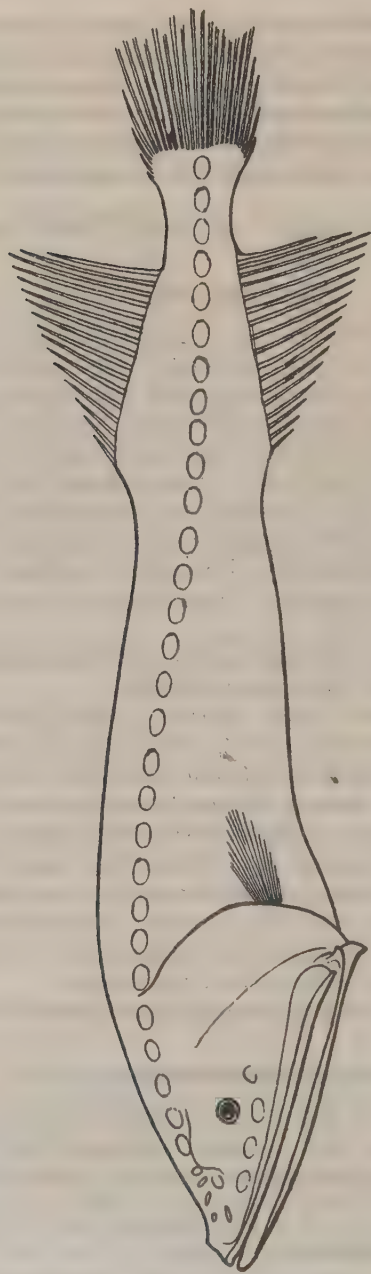


Figure 6. *Cetomimus kerdops* n. sp. Drawn by Y. H. Olsen.

Gills 3, a small opening behind the third. Gill rakers absent. Eyes rudimentary. Head deep, strongly compressed. Trunk very attenuate. Dorsal and anal fin bases elevated, compressed. Caudal peduncle, slender, compressed. Caudal moderate, only slightly emarginate. Pectorals very low. Dorsal and anal fins with numerous rays (D about 30, A about 27) of fairly uniform length, giving to these fins a rectangular rather than triangular outline. Mouth very large. Articular bone of lower jaw without lateral protuberance behind end of maxillary. Teeth minute and stubby, in dense bands on jaws, palatines, pterygoids, and throughout the entire length of the long and very narrow tongue, in a heart-shaped patch on vomer, and in a series of patches on each of the three free gill arches, and on the upper pharyngeals.

Genotype: *Cetostomus regani* Zugmayer.¹⁹

Cetostomus regani Zugmayer

Cetostomus regani Zugmayer, Bull. Inst. Oceanogr. Monaco No. 288, 1914, p. 4.
Cetomimus regani Parr, Bull. Bingham Oceanogr. Coll. Vol. III, Art. 3, 1928, p. 174, fig. 42; Occas. Pap. Bingham Oceanogr. Coll. No. 2, 1929, pp. 23-27, figs. 9-10.

In conjunction with the revision of the other species of Cetomimidae available to the author, a more complete set of measurements of *C. regani* may be in place. Although the specimen has been stained with alizarin and has been cleared and kept in glycerin since 1928, in which process its length without caudal has shrunk from 141 mm. to 130 mm., it does not appear to have changed significantly in its proportions. This may be seen from a comparison of the following new measurements with the old records of some of the proportions in the fresh (formalin) specimen.

Length without caudal fin 130 mm. (141 mm., 1928). Proportions in per cent of these measurements: Length of head 30.0 (29.1—1928). Greatest width of skull 9.2 (9.2—1928). Snout to eye approximately²⁰ 11 (10.6—1928). Length of maxillary 21.7 (20.6—1928). Length of lower jaw 23.1 (21.3—1928). Snout to end of skull 18.5. Greatest depth of head (supraoccipital to corner of angular) 19.6. (Least depth of trunk anterior to vertical fins 5.0—1928). Least depth of caudal peduncle 3.5 (3.5—1928). Greatest height between bases of dorsal and anal rays 13.1 (12.8—1928). Height of caudal fin base 7.9. Snout to dorsal fin 58 (57—1928). Length of pectorals 9.2. Length of caudal 10.8. Longest dorsal ray 11.5. Longest anal ray 10.0. Origin of dorsal fin to end of hypural

¹⁹ The analysis of the genus and species is here based upon specimen No. 2132 of the Bingham Oceanographic Collection. The author is indebted to Dr. Richard of the Monaco Museum for verifying and confirming the identification by comparing the previously published description and figure of the Bingham Collection specimen (Parr, 1928, loc. cit.) with the type in the Monaco collection.

²⁰ Both eyes partly detached, accurate position therefore somewhat uncertain, which was true also in 1928.

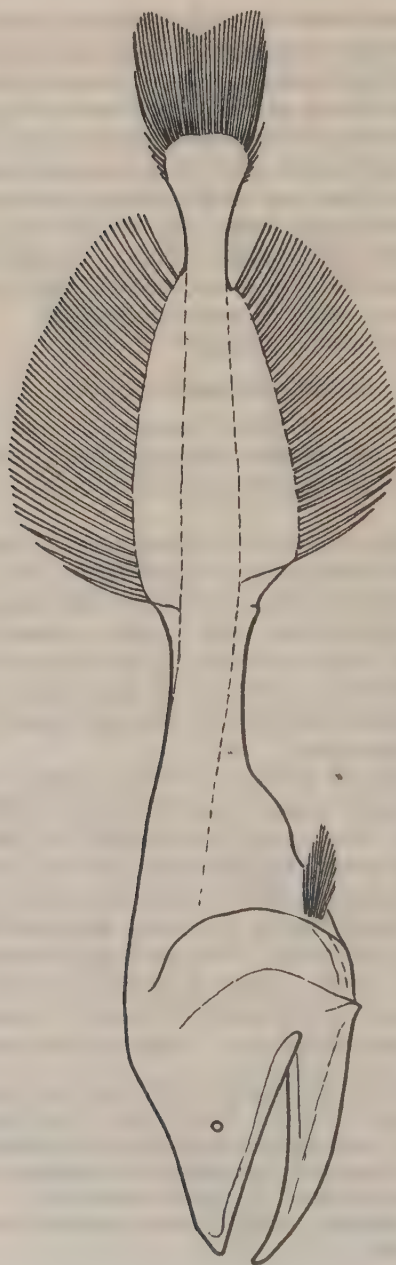


Figure 7. *Cetostomus regani* Zugmayer. Drawn by Y. H. Olsen.

42.3 (43.3—1928; base of dorsal 30.5 + caudal peduncle 12.8). Origin of anal fin to end of hypural 39.6. End of dorsal fin base to end of hypural 13.3 (12.8—1928). End of anal fin base to end of hypural 14.2.

D. 30. A. 27. P. 18. 51 vertebrae.

Known only from the Atlantic (2 specimens).

GYRINOMIMUS NEW GENUS

Gills 3, a small opening behind the third. Gill rakers absent. Eyes minute. Head broad, depressed, tadpole-like. Snout transverse, mouth widely arched. Tail moderately compressed, caudal peduncle slender. Dorsal and anal fins with less than 20 rays each, the rays increasing conspicuously in size towards the posterior rounded corners of these fins. Caudal moderate, slightly emarginate. Pectorals very low, ventral, inserted anteriorly to the posterior end of the gill cover. Mouth very large. Lower jaw without lateral protuberance. Jaws with small, slender, subequal teeth arranged in a number of very precise, close-set series. Similar teeth on vomer, palatines and pterygoids. An oval shield of concentrically-arranged, curved teeth on the tongue. Maxillary dentition posteriorly entirely confined to the external surface. Slightly elongate small teeth in the gill arches. Lateral line pores on the head large, wide and simple, those of the trunk and tail, about 15 in number, with a pointed flap from their anterior margin increasing in size towards the tail until it completely covers the lateral aspect of the pores on the caudal peduncle. Outer wall of lateral line tube, and flaps, with a series of minute papillate organs externally (see dorsal view, fig. 8). Isolated papillae of a similar nature on the nape, and a semicircular pattern of minute pores above and behind the eyes.

Genotype: *Gyrinomimus myersi* n. sp.

Gyrinomimus myersi n. sp.

Cetomimus gilli (nec. Goode and Bean) Parr: Bull. Bingham Oceanogr. Coll. Vol. III, Art. 3, 1928, p. 176.

Length without caudal fin (to end of hypural) 108 mm. Proportions in per cent of this measurement: Length of head 32. Length of maxillary 29.3. Length of lower jaw 27.8. Interocular width 15.7. Interorbital width (skull) 10.9. Snout to eye 12.5. Greatest external width between rami of lower jaw 22.2 in the undisturbed specimen as preserved, minimum possible natural value for this measurement 19.5 per cent. Width between tops of gill slits 14.8. Snout to top of gill slit 24–25. Snout to pectorals 27.8. Length of pectorals 8.5. Snout to origin of dorsal fin 71.7. Origin of dorsal to base of caudal fin 30.6. Base of dorsal fin 17.6. Snout to origin of anal fin 70.5. Base of anal fin 15.7. Greatest depth 25.9. Depth at origin of dorsal fin 16.7. Least depth of caudal peduncle 6.0.

D. $16\frac{1}{2}$. A. $16\frac{1}{2}$. C. 19. P. 19. 15 pores in lateral line from top of gill opening to end.

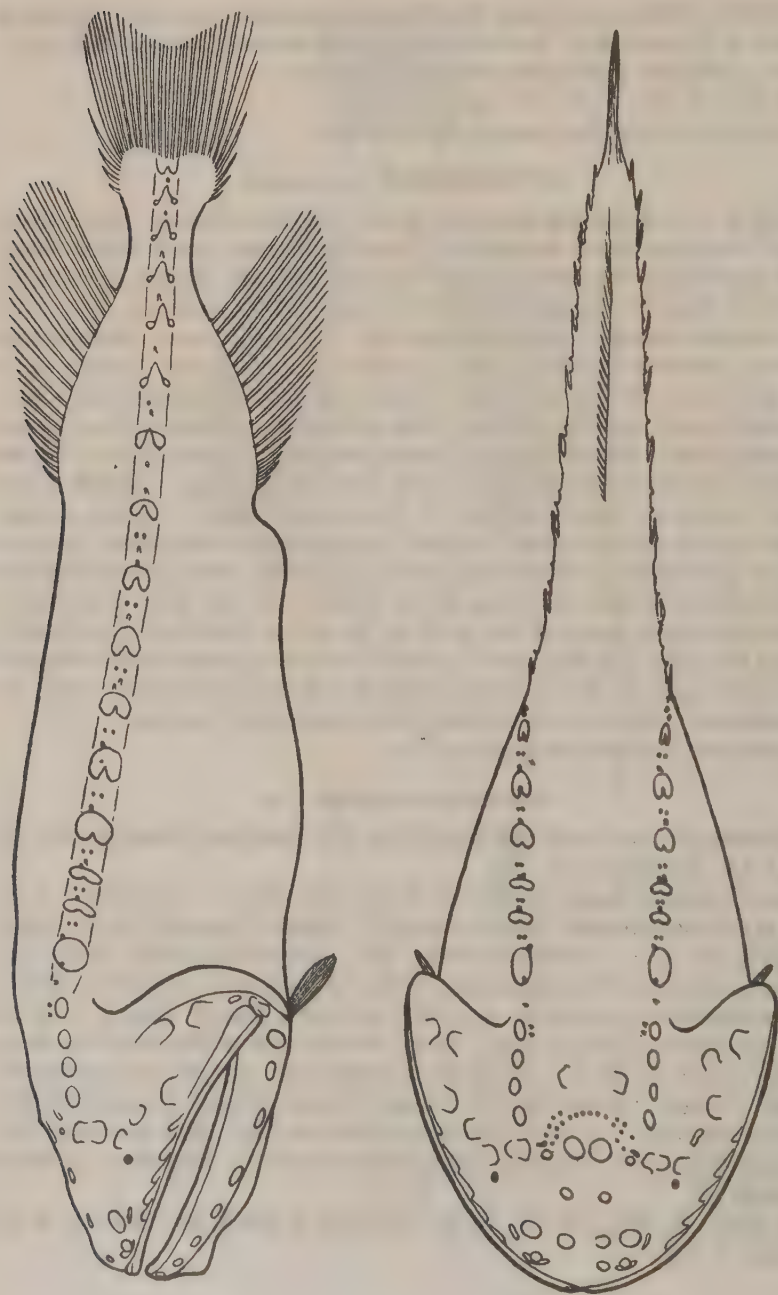


Figure 8. *Gyrinotinus mayersi* n. sp. Lateral view above; dorsal view below. Drawn by Y. H. Olsen.

Head broad, depressed, with the appearance of being cavernous under the skin. Mouth enormous, oblique. Jaws slightly arched (artefact ?) in lateral view. Lower jaw without spines or prominences posteriorly. Dentition in the jaws as shown in figure 9. The upper jaw starts with 3 series of teeth (the main series of the upper jaw) anteriorly increasing in size inwards. The inner two

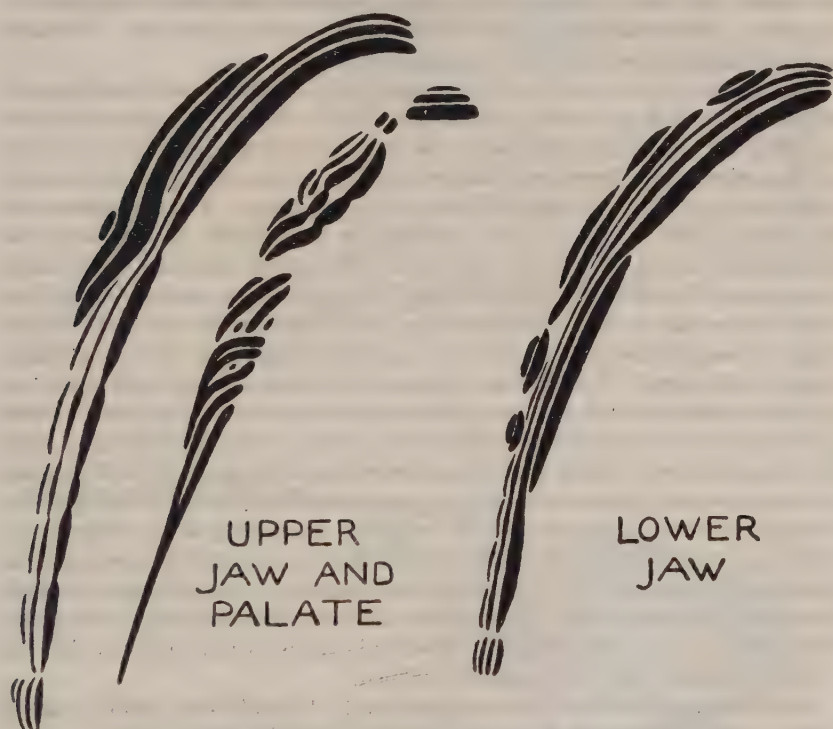


Figure 9. Diagram of upper and lower dentition-pattern in *Gyrinomimus myersi* n. sp. Width of band used to indicate size of teeth in series. Prepared by author.

series are continuous throughout the length of the premaxillary, the third also extending with interruptions to the end of the jaw. A double series of relatively large teeth with a couple of teeth of a third row form an elongate patch external to the three inner series of teeth on the anterior half of the jaw. A fragment of a fourth series is also to be found in the terminal patch of teeth in the upper jaw otherwise formed by semi-separated segments of the three main series of dentition. No separate patch of inner teeth in upper jaw. The dentition of the lower jaw starts with four separate series at the anterior end (the four "main" series of the lower jaw), increasing in size towards the interior of the mouth.

Of these series the inner two are continuous and the third extends discontinuously to the end of the dentary. The fourth (outer) series, however, is soon interrupted by a series of external patches of larger dentition, each patch being made up of a double row of teeth. These external patches of teeth in the lower jaw seem variable both in regard to their number and the length of each. In the lower jaw there is also an extra internal patch of dentition consisting of a single row of relatively large teeth in the middle portion of the jaw. Terminal patch of teeth in lower jaw with four short series.

In the inner two rows of teeth in the upper jaw in particular, less conspicuously elsewhere, there is a tendency for the series to be divided into segments characterized by a decrease in the size of the teeth towards the posterior end of one of these segments followed by a sudden increase at the anterior end of the next. These segments are also roughly indicated in the figure. The arrangement of the teeth in the jaws is not only striking by the absolute perfection of the longitudinal line-up of the series but also by the extreme precision of the transverse alternation of teeth in the main series²¹ in which the numbers of teeth do not increase with a decrease in their size, each series on the contrary being in exact correspondence with the others in regard to counts and alternate arrangement at all points. The external patches of dentition in upper and lower jaw and the internal patch in the lower form separate systems in which the numbers and insertions of the teeth do not join the pattern of the corresponding parts of the main series. Vomer with three precise transverse series of teeth forming a triangular group pointed forward; the inner series being the longest and having the largest teeth. Palatine with a system of undulating series of teeth. A similar pattern (see figure 9) is also observed in the anterior broad portion of the pterygoid dentition which is continued backwards as a double series of teeth fusing into one posteriorly. The palatine and pterygoid dentition is somewhat less precise in its pattern than are the series in the jaws and on vomer; but the several series are still very distinctly defined.

Profiles of dorsal and anal fins obliquely oval. Caudal short, slightly emarginate. Uniform brownish-black, fins included (purplish-black in life).

Named for Dr. George S. Myers of the U. S. National Museum.

Type specimen No. 2111 of the Bingham Oceanographic Collection. Pawnee 1927, station 18, March 18, 23° 39' N. 76° 41' W., 7000 feet wire (approximately 700 fathoms vertical depth). Only the type known.

GENUS *DERICHTHYS* Gill

Derichthys serpentinus Gill

Derichthys serpentinus Gill 1887, American Naturalist, Vol. XVIII, p. 433; Goode and Bean 1895, Oceanic Ichthyology, p. 161, fig. 169.

²¹ 3 in upper jaw, 3 + fragment of fourth anteriorly in lower jaw.

Derichthys iselini Borodin 1929, Proc. New England Zool. Club, Vol. X, p. 110; 1931, Bull. Mus. Comp. Zool. Vol. LXXII, No. 3, p. 75, pl. III, fig. 2.

It is unfortunate that the condition of the type specimen of *D. serpentinus* no longer makes possible any comparison with the described characters of *D.*

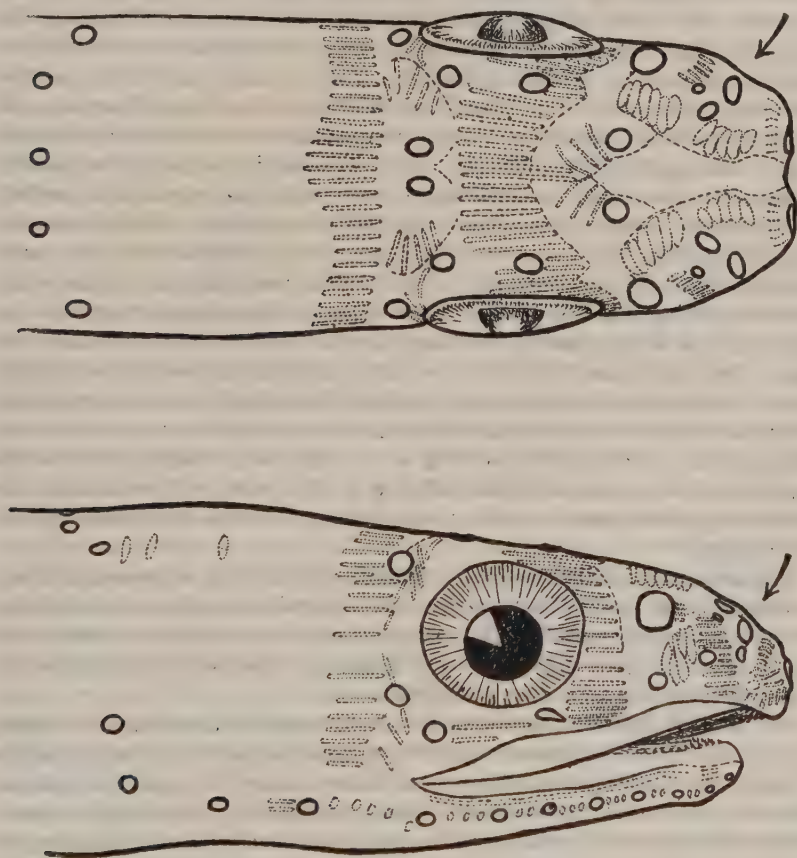


Figure 10. Head of *Derichthys serpentinus* Gill. Dorsal view above; lateral view below. Arrows indicate true anterior nostril. Y. H. Olsen and author.

iselini, but since, on the other hand, the existing description and figure of *D. serpentinus*, although relatively lacking in details, show no features which are not also common to *D. iselini*, it seems clear that Gill's specific designation should have been considered available for Borodin's specimen. A multiplication of the nomenclature is therefore at present devoid of any meaning whatever

and may only become justified if future investigations should serve to establish the actual existence of more than one species in the North Atlantic, but there is no evidence as yet to suggest this possibility.

The statements as to the conspicuousness or inconspicuousness of the lateral line are obviously highly subjective, dependent upon the comparison one has in mind. The author would personally be inclined to consider the lateral line as being neither conspicuous nor inconspicuous. Distinction for *D. iselini* has also been claimed by Borodin on the basis of the character and arrangement of its nostrils, but a careful probing of the peculiar anterior pair of pores on the snout described by Borodin as anterior nostrils has failed to show any relations to the nasal organs at all, although a tortuous connection might still be possible, while, on the other hand, one of the lateral pores farther back represents a perfectly normal anterior nostril in accordance with Gill's description. That the peculiar shape of the dorsal fin may have been overlooked or interpreted as purely accidental and therefore omitted in the original description and figure is not at all surprising when we consider the nature of this character and the fact that only one single, possibly shrunken, alcohol specimen was available at the time. Borodin's statement (1931, *loc. cit.* p. 75) that *D. iselini* should differ from *D. serpentinus* by the shape of its dorsal fin is therefore not warranted by any positive knowledge of the actual shape of this fin in the type of *D. serpentinus* and can be disregarded so long as no evidence is available to show the existence of two separate species differing on this point. There is thus altogether no positive reason at all for maintaining *D. iselini* as distinct from *D. serpentinus*.

The accompanying figure shows in detail the distribution of pores and dermal striations on the head in the specimen here reported upon, with arrows pointing to the true anterior nostril. The pattern of pores and striations shown in this figure agrees in detail with that found in the type specimen of *D. iselini* with which the drawings have been compared.

The dermal striations consist of low but sharply defined ridges of unpigmented soft tissues and are arranged in a well-marked pattern, the chief features of which are a medial band of narrow striations across the nape and continued down on each cheek immediately behind the eyes, an interorbital band of similar striations continued down the sides of the head in front of the eyes, and a pair of rostral bands, one on each side, stretching as a curved series of wider ridges from above each posterior nostril towards the snout. There are also a number of minor groups of these striations present as shown in the figure. There is a large posterior nostril and a somewhat smaller anterior one, with a very small pore between them which also seems to lead into the nasal cavity. The peculiar pair of pores at the end of the snout, interpreted by Borodin as anterior nostrils, are probably the terminal pores of the supraorbital branches of the lateral line system and the pore above and slightly behind each anterior nostril would also seem to belong in this series, while the pore immediately

below the anterior nostril and the one farther back at the lower margin of the nasal cavity are undoubtedly connected with the infra-orbital branch of the lateral line system on the head.

GENUS *GIBBERICHTHYS* Parr

Gibberichthys Parr 1933, Bull. Bingham Oceanogr. Coll. Vol. III, Art. 6. p. 5.

The capture of a much larger specimen of this genus, which was previously known only from a single small specimen about 32 mm. long without caudal fin, makes it possible to add several new features to the generic diagnosis. Most significant of the newly discovered characters is probably the fact that the squamation, which is complete on trunk and tail and consists of thin, but not excessively thin, cycloid scales, is entirely subcutaneous, i. e., the scale pockets are completely closed and covered by a thin, generally transparent, continuous sheet of epidermis without openings of any kind. The papillate lateral line organs arise from this external cuticle, 6-8 in a vertical row across the middle of two vertically adjacent scales.²² Head without scales, all ridges and crests spinulose, as previously described. A second important feature is found in the character of the 5 anterior dorsal and the 3 anterior anal spines. These spines are very strong and entirely rigid, the proximal portion of each being flattened and broadened to form a sharply gabled basal plate which is contiguous to the basal plates of the adjacent spines anteriorly and posteriorly. Whether these structures should be interpreted as scutes modified into spines or spiny fin rays modified into spiny scutes is, of course, only a matter of conjecture on which the author has no definite opinion, although their derivation from spiny fin rays is perhaps the most plausible interpretation of their origin. Behind these fixed spines follows one simple movable spine of the ordinary type both in dorsal and in anal fin. In the much smaller type specimen of *G. pumilus* the movable anal spine is still so soft and unclearly differentiated from the following soft fin rays that it was originally counted and drawn as one of these. In the larger specimen both the dorsal and anal movable spines are stiff and well differentiated.

The posterior nostril of the large specimen has a long, pointed, triangular flap arising from the lower half of its anterior border. In the smaller specimen this flap is only indicated by a short, pointed projection not mentioned in the previous description. As developed in the adult, this flap is undoubtedly a significant distinctive character.

In the adult the very wide pores of the younger specimen are relatively reduced and are no longer conspicuous by any unusual size compared with the pores of other Beryciformes (see figure 11). In all other respects the original generic diagnosis remains unmodified.

²² Looking from the exterior as if they were one single greatly enlarged lateral line scale, their separation being obscured by a lateral-line streak of pigmentation in the covering epidermis.

Gibberichthys pumilus Parr

Gibberichthys pumilus Parr 1933, Bull. Bingham Oceanogr. Coll. Vol. III, Art. 6, p. 5, fig. 1.

Length without caudal fin 91 mm. Proportions in per cent of length without caudal fin: Greatest depth of body 29.1. Length of head 42.3. Length of lower jaw 26.4. Length of maxillary 24.7. Length of snout 15.4. Interorbital width 17.0. Diameter of eye 6.7. Depth of caudal peduncle 10.5. Length of caudal peduncle from base of anal fin to base of middle caudal rays 23.1. Snout to ventral fins 49.5. Snout to anal fin 59.3. Snout to first dorsal spine (scute) 51.0. Snout to first soft dorsal fin ray 65.4. Length of pectorals 17.0. Length of ventrals 9.3. Length of caudal fin lobes 20.6. Length of middle caudal rays 10.5.

D. V + I + 9. A. III + I + 8. P. 15. V. I + 5. C. 19, with 7 procurrent spines above and 6 below. Twenty-eight scales in a longitudinal series under ("in") the lateral line. Four scales above the middle of the lateral line organs and about 15 below to the origin of anal fin. 6/15 long gill rakers.

The above-recorded measurements differ from those of the type specimen (31.5 mm. long exclusive of caudal) only in regard to proportions in which such differences might be expected by a comparison with a specimen of so much smaller size (head, eyes, and depth of body relatively smaller in the adult specimen here reported upon). All pectoral rays except the upper and lower two, all dorsal and anal soft rays except the first one in each fin, and all caudal rays except the upper and lower one (17 rays) are branched. Both the fixed and the movable spines in dorsal and anal fins are free from the membrane connecting the soft rays. The scales are obscured by dark pigmentation on the external epidermis in the area covered by the pectoral fin when applied to the body, in a narrow, oblique belt from the bases of the pectorals to the axils of the ventrals, in a band along the bases of dorsal and anal fin and in a narrow streak along the middle of the lateral line. Otherwise the dark pigmentation of trunk and tail is found only underneath the scales and the external transparent epidermis, producing the effect in the preserved specimen of purplish black seen through a slightly opalescent film. Head and fins uniformly black. The pores on the head are relatively much smaller in the adult than in the juvenile type and the superficial skeletal parts more spinulose, with the preopercular spines of the juvenile presented only by spinulose prominences, as is also the opercular ridge and spine.

GENUS BROTULOTAENIA Parr 1933***Brotulotaenia crassa* n. sp.**

Length without caudal fin 302 mm. Proportions in per cent of length without caudal fin: Length of head 11.77. Snout 3.05. Diameter of eye 2.85.



Figure 11. *Gibberichthys pumilus* Parr. Specimen 91 mm. long. Drawn by Y. H. Olsen.

Length of maxillary 6.39. Interorbital width 2.91. Snout to anal fin 27.5. Depth of body 7.4. Length of pectorals 2.75.

D. 126-127. A. 98-100. C. 6. P. 24. Br. 7.

In the general appearance of their various parts considered separately (e. g., head compared with head, gill covers with gill covers, etc.) *B. nigra* (Parr 1933, Bull. Bingham Oceanogr. Coll. Vol. III, Art. 6, p. 50, fig. 19) and our new species, *B. crassa*, agree so completely with each other that it is impossible to discover any structural detail in their external characters by which they can be distinguished from each other. It is only in the proportions of these various parts to each other and to the entire fish that the two species differ so conspicuously that the author feels entirely convinced of their specific distinctness. Since the very elongate shape of these fishes somewhat obscures the significance of the differences in their proportions, when these are expressed in per cent of the total length without caudal fin, the accompanying illustration of the types of both species, drawn to the same scale, is presented for a visual comparison which should serve to bring out the importance of the difference in relative measurements much more clearly than do the measurements themselves, or any verbal description. It is very fortunate that the two types, which are also the only specimens known of each species, have so very nearly the same total length (302 and 286 mm. respectively) that the possibility of ontogenetic changes accounting for the differences in their proportions may safely be ruled out.

In *B. crassa* the length of the head is more than 11 (11.7), in *B. nigra* less than 10 (9.5) per cent of the length without caudal fin, the actual difference between the relative lengths of the heads in the two type specimens being over 2 per cent of the length without caudal. In accordance with the larger size of the head, all parts of the head such as eyes, snout, maxillary etc. are also larger and the distance from snout to anal fin slightly greater in *B. crassa* than in *B. nigra*. Furthermore, the greatest depth of body in *B. crassa* is nearly $7\frac{1}{2}$ (7.4), in *B. nigra* only about 6 (5.9) per cent of the length without caudal. Finally it has been discovered by dissection that instead of the 5 distinct, finger-like pyloric caeca of *B. nigra*, there are in *B. crassa* only 4 or 5 very shallow and indistinct billow-like evaginations of the gut, which is very thin-walled and expanded immediately before it joins the pylorus.

Dentition, squamation, vertical fins, details of head and general appearance as in the generic diagnosis (Parr 1933, p. 48).

Maxillary reaching to vertical from posterior margin of orbit. Pseudo-branchiae of 5 very small filaments each. Gill rakers represented by 4/11 spinigerous stubs. External color dusky brownish grey (conspicuously paler than the deep black of *B. nigra*). Inner lining of mouth and gill cavity, peritoneum and outer mesenteries deep black.

Type specimen No. 3205 of the Bingham Oceanographic Collection. Atlantis Station 1478.

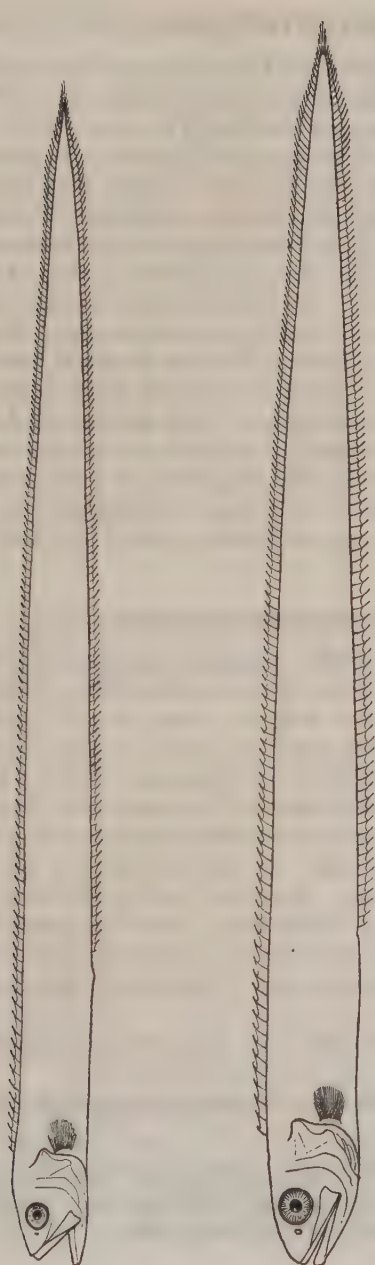


Figure 12. *Brotulotaenia nigra* Parr, 286 mm. long, above. *Brotulotaenia crassa* n. sp., 302 mm. long. Both drawn to the same scale by Y. H. Olsen.

GENUS **TREMATORHYNCHUS** Regan and Trewavas 1932

With 11 known genera of female Oneirodidae and little chance of establishing the specific identity of males and females, it would seem futile to proceed with the introduction of new genera based upon the males only. Although several of its features might have been considered significant of generic distinctions, the new male described in the following has therefore been referred to the genus *Trematorhynchus*, as a convenient general designation for all male Oneirodidae. While it seems advisable to the author thus to refrain from needless duplication of generic nomenclature, the ratio of 72 known species of females to only 3 previously known species of male Oneirodidae on the other hand points to the necessity of making sharper specific distinctions among the males, since the disparity in the number of male and female species is undoubtedly in a considerable measure due to a failure to recognize specific distinctness among the males due to the inconspicuousness of their morphological differences. Thus the author is strongly inclined to question the appropriateness of grouping together under the single specific designation of *Trematorhynchus leucorhinus* Regan 22²³ male specimens with a range of variation in fin counts of D. 4-7 and A. 4-6, while the female Oneirodidae average less than 1.5 known specimens of each species.

***Trematorhynchus phyllodon* n. sp.**

Anterior and posterior nostril contiguous, near the end of the snout far away from the eyes, which are lateral and of moderate size. Head broad, somewhat depressed, very large, and without spines. Snout square. Mouth small, transverse, horizontal, not reaching to eyes. Jaws without teeth. Snout without normal, rostral denticles but with a pair of small, wing-like bony plates diverging from bases near the median (see figure 13 C), both bones apparently somewhat damaged but with distinct indications of a series of pointed prominences along their anterior edge. No predental teeth or any other dentition in the lower jaw. Skin naked. Body short and thick. D. 6. A. 6. P. 15-16. C. 2 above + 4 branched + 2 (3?) below. Dorsal and anal fins projecting almost directly from their bases, which are only slightly forward of the external fins.

Length without caudal fin 14 mm. Total length 20.5 mm. Greatest width of skull 4.6 mm.

Skin on snout torn and partly lost. Rest of body including fin rays uniformly dark.

Type specimen No. 3206 of the Bingham Oceanographic Collection. Atlantis station 1478.

²³ 17 specimens recorded by Regan (1926, Danish "Dana" Exp. 1920-22, Oceanogr. Rep. No. 2, p. 44) + 5 specimens recorded by Regan and Trewavas (1932, Carlsberg Found. Oceanogr. Exp. 1928-30. Rep. No. 2, p. 91).

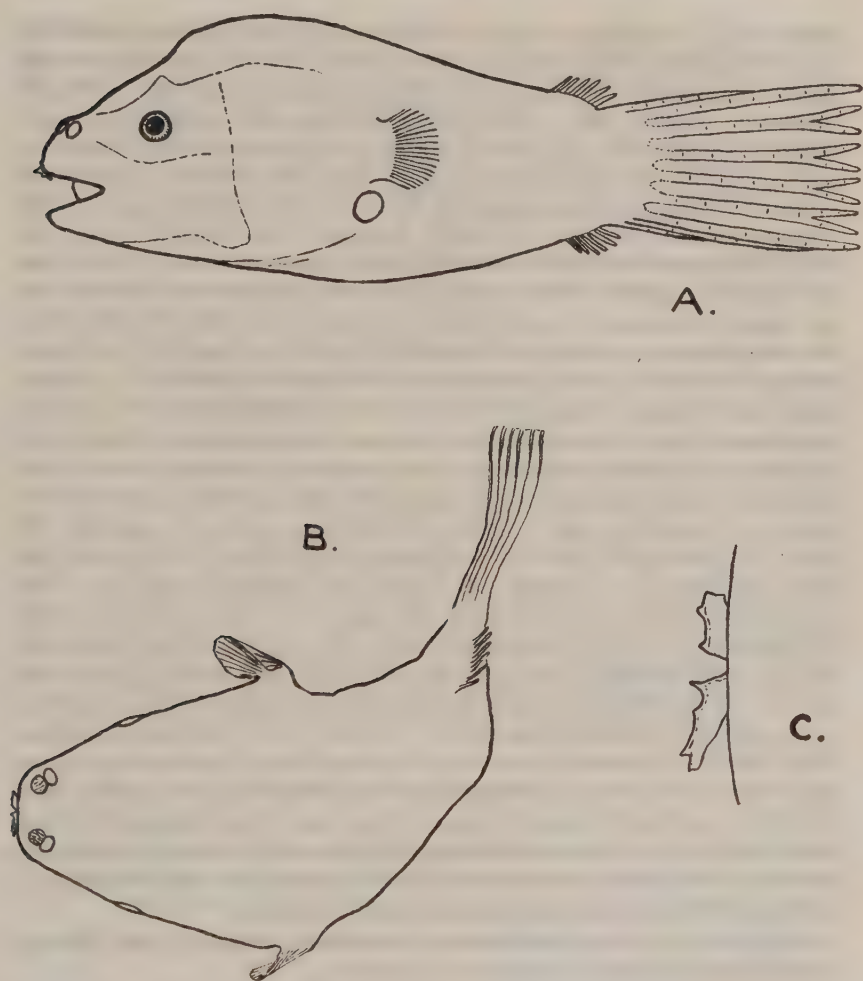


Figure 13. *Trematorhynchus phyllodon* n. sp. A. Lateral view of artificially straightened specimen. B. Natural dorsal view. C. Enlarged dorsal view of rostral denticles.

GENUS **LINOPHRYNE** Collet

By analysis of the genus *Linophryne* it becomes perfectly evident that the differences upon which the distinctions between its species are based are of two entirely separate orders of magnitude and taxonomic significance, namely, (1) differences in the fundamental structural pattern of the barbel and the terminal appendages of the luminous bulb distinguishing various species singly or in

groups, and (2) variations in minor details of barbels and terminal appendages on the bulb within certain groups of species in which the fundamental structural patterns of both of these organs remain the same throughout. Thus, for instance, *L. coronata* Parr, *L. longibarbata* Borodin, and a new form to be described in the following, all agree in having a long, simple barbel ending in a small tassel of minute branches at the tip, and are also identical in the general structure of the terminal appendages on their bulbs, which consist of an anterior columnar process, more or less deeply bifurcated longitudinally at the tip, followed by a transverse pair of simple, slightly smaller columns, with a single small fin-like projection behind. Opposed to these similarities of structure are only minor differences in such features of detail as the depth to which the anterior columnar appendage on the bulb is divided, the length of the barbel and small variations on the general pattern of its tassel. Similarly *L. arborifer* Regan and *L. eupogon* Regan and Trewavas both have the same trifid terminal appendage on the bulb and both have a much branched barbel. Under these circumstances a simple subdivision of the genus into a number of equivalent species, only, is clearly inadequate to express the actual existence of two distinct degrees of similarities and probable relationships among the species. To achieve a more natural systematic expression of these facts, two ways of procedure are open, (1) to arrange the species into subgenera according to the fundamental structure of their bulbs and barbels, or (2) to treat the forms differing merely on minor points as subspecies only, of a species defined by their common characteristics. The latter procedure has been adopted here for two reasons. In the first place, it does not unnecessarily multiply the nomenclature by the introduction of new designations. Secondly, only 3 species of *Linophryne* are known from 2 specimens each, the rest being known from single specimens only. Since clearly every new specimen cannot also be a new species, there is therefore considerable reason to suspect that many of the differences in minor details may prove to represent individual variations only, leading to an ultimate reduction of the present nomenclature, and in realization of this possibility an elevation of the groups to higher ranks would be illogical.

On the basis of these considerations, the author will propose the following synoptic rearrangement of the genus *Linophryne*.

Synopsis of the species of *Linophryne*

Inadequately known forms:

1. *Linophryne arcturi* (Beebe 1926).²⁴ Barbel long, undivided (figure shows minute filaments arising from its distal portion). Bulb on illicium with a long, black, simple terminal column changing abruptly into a thin, colorless, distal filament. Description inadequate.

²⁴ *Diaboloidium arcturi* Beebe: Bull. N. Y. Zool. Soc. Vol. XXIX, No. 2. March-April, 1926, p. 80, with figure.

2. *Linophryne bicornis* Parr 1927.²⁵ A strong, tapering, simple, lateral appendage arising on each side of the bulb of the illicium near its middle, with a small dermal protuberance beneath each appendage on the proximal portion of the bulb. Barbel and distal portion of bulb lost in the type. The introduction of a new species on the basis of such a damaged specimen was perhaps unfortunate, but the species still remains distinct from any other described form of *Linophryne* by the features of the preserved portion of its bulb.

I. Processes and appendages on the bulb of the illicium not confined to its distal surface only, but also arising in one or two lateral series from its middle and usually also its proximal portions.

A. A single series of numerous simple (?) filaments on each side of bulb. Barbel split into a bundle of (about 16) equal, simple, thin branches arising together from a short basal peduncle... *L. polypogon* Regan

B. Bulb with a series of 6 or 7 branched filaments on each side. Barbel slender, simple, but for a short series of minute branches forming a very small tassel at its distal end... *L. racemifera* Regan and Trewavas

C. Bulb with a double row of branched appendages on each side and a simple, short, tapering filament at its distal end. Two branches arising in sequence in the proximal part of the distal three-fifths of the short barbel. Main stem beyond the last branch with a minute filament and a single series of stalked to sessile minute tubercles. Similar tubercles also in an irregular series on the proximal branch and in a single pair about the middle of the second branch.

L. brevibarbis Parr

II. Processes and appendages on bulb of illicium confined to its distal surface only.²⁶

A. Bulb with only a single, simple, distal filament. Barbel bearing a lateral branch and then bifurcating; each terminal branch with distal filaments..... *L. macrodon* Regan

B. Bulb continued into a stout terminal process²⁷ bearing a bundle of

²⁵ *Linophryne bicornis* Parr: Bull. Bingham Oceanogr. Coll. Vol. III, Art. 1, 1927, p. 9, fig. 2.

²⁶ Without extending beyond the distal hemisphere of the bulb the appendages in this group may reach farther down in the posterior median line than they do laterally, where they are never found in series or single processes extending to or beyond the equatorial region of the bulb as they always do in group I.

²⁷ Judging from the figure (Regan and Trewavas 1932, fig. 167, p. 109) there can hardly be any doubt that the distal three-fifths of the organ regarded by Regan and Trewavas as simply a part of the bulb is rather comparable with the parts designated as terminal appendages in other species. With bulb is here only understood that portion of the entire luminous organ which is characterized by the internal globular

distal filaments. Other appendages beside and behind this terminal process. Barbel short, slender, trifold distally, with simple branches.

L. argyresca Regan and Trewavas

- C. Bulb with a stout terminal process carrying 3 short filaments, but with no other appendages. Barbel consisting of 3 short stout branches, each with a single series of tubercles or stout tentacles.

L. brevibarbata Beebe

- D. Bulb with only two minute distal filaments. Barbel bifid, divided distally into two pointed blades, each with a series of white tubercles.

L. lucifera Collet

- E. Bulb with an anterior pair of long, fringed, filaments, a median short papilla bearing 3 small filaments, two long simple lateral filaments on each side, and a similar filament behind, all arising from its distal surface. Barbel very short, dividing into a group of small branches in its distal third. *L. corymbifera* Regan and Trewavas

- F. Bulb with a single trifold terminal appendage consisting of a long tapering median filament and two shorter lateral lobes arising together from a short basal peduncle. Barbel much branched almost from its base: *L. arborifer* Regan

1. Terminal appendage on bulb about twice the length of the bulb itself. Barbel as long as fish. *L. arborifer arborifer* Regan

2. Terminal appendage on bulb about $\frac{2}{3}$ or less of the length of the bulb itself. Length of barbel to end of terminal filament only about $\frac{1}{3}$ of the length without caudal fin.

L. arborifer eupogon Regan and Trewavas

- G. Terminal appendages on bulb composed of a stout anterior bifid process, followed by a pair of somewhat shorter, thick, finger-like or tapering simple appendages, with a small pointed, fin-like median process behind. Barbel slender, with a small tassel of minute branches at its distal end but otherwise unbranched. *L. coronata* Parr

1. Terminal appendages white, shorter than bulb, bifid distal points of anterior process fairly large, about $\frac{1}{3}$ of the total length of the entire appendage. Bulb nearly as long as stem. Barbel shorter than body. Lower jaw about $\frac{2}{5}$ of length without caudal. *L. coronata coronata* Parr

2. Terminal appendages pigmented, slightly shorter than bulb, anterior process deeply split ($\frac{2}{5}$ to $\frac{1}{2}$ of its length). Bulb much shorter than stem. Barbel nearly twice as long as body

body at the end of the illicium, while any part arising distally from this is considered in the group of terminal organs or appendages.

(exclusive of caudal fin). Lower jaw about $1/2$ or more of length without caudal. *L. coronata longibarbata* Borodin

3. Terminal appendages white, much longer than bulb, bifid points on anterior process in the form of two minute lobes occupying only about one-eighth of the entire length of the appendage. Bulb much shorter than stem. Barbel nearly 3 ($2\frac{3}{4}$) times as long as body without caudal. Lower jaw about $1/2$ of length without caudal.

L. coronata diphlegma n. subsp.

***Linophryne arborifera* Regan**

Linophryne arborifer Regan 1925: Ann. Mag. Nat. Hist. Ser. 9, Vol. XV, p. 564.

The reasons for combining *L. arborifer* Regan and *L. eupogon* Regan and Trewavas as subspecies under the common specific designation of *L. arborifer* have already been mentioned on page 42 and will be further apparent from the preceding key. It might also be pointed out that both "subspecies" have been recorded from the North Atlantic only.

***Linophryne arborifera arborifera* Regan**

Linophryne arborifer Regan 1925: Ann. Mag. Nat. Hist. Ser. 9, Vol. XV, p. 564;

1926: Oceanogr. Rep. No. 2, Danish Dana Exp. 1920-22, p. 24, pl. III, fig. 1.

Linophryne arborifera Regan and Trewavas 1932: Carlsberg Found. Oceanogr. Exp. 1928-30. Rep. No. 2, p. 111.

In regard to the structure of the barbel in this subspecies our information is still very inadequate although the original description of this organ: "barbel as long as fish, much branched, the ultimate branches being filamentous" (Regan 1925; 1926) has been somewhat expanded by Regan and Trewavas (1932) in the statement: "barbel as long as fish, with several much branched translucent branches from a short blackish peduncle; posterior branch strongest and longest, distally divided into two main branches; ultimate branches filaments, with series of swellings." Apart from the stated length of the barbel, and the distal (as opposed to proximal) insertion of the largest sub-branch of the posterior branch, it will be found by comparison with the accompanying figure 14 and the following discussion of *L. arborifera eupogon* that even Regan and Trewavas's description is still on all other points merely general for both sub-species, if such they are, without any distinctively defined details which might help in their segregation.

The possibility that both the size of the barbel and the position of the main branching point of its posterior stem may be merely due to differences in the ages of the specimens compared will be fully discussed under the following sub-species:

Linophryne arborifera eupogon Regan and Trewavas

Linophryne eupogon Regan and Trewavas 1932: Carlsberg Found. Oceanogr. Exp. 1928-30. Rep. No. 2, p. 110.

Linophryne arborifer Parr 1927: Bull. Bingham Oceanogr. Coll. Vol. III, Art. 1, p. 10, fig. 3.

The species *L. eupogon* has been introduced by Regan and Trewavas solely on the basis of the description and figure of specimen No. 2029 of the Bingham Oceanographic Collection, previously given by the present writer (Parr 1927, loc. cit.) under the designation of *L. arborifer* Regan. The said specimen thus becomes the type of Regan and Trewavas' nominal species, and a more detailed discussion and illustration of its taxonomically most important feature, viz.: the barbel, may therefore be in place. In the previously published figure of the barbel of this specimen (Parr 1927, fig. 3) the artist has merely endeavored to give a general impression of its appearance and the main features of its system of branches. In the accompanying figure 14, prepared by Y. H. Olsen under the supervision of the writer, an effort has been made to trace every ultimate branch and terminal filament so as to give a more complete and detailed picture of their complex system.²⁸

A pair of lateral and 2 posterior median main branches originate from the thick black basal part of the barbel in such rapid succession that they all appear to arise together from a short peduncle. Each branch in the anterior pair bifurcates transversely almost from its base, the medial sub-branch being larger than the lateral one, and both sub-branches being again more or less bifurcated at the tip. The first posterior main branch originates immediately behind the anterior lateral pair and carries a single series of 10 sub-branches along its entire anterior surface from immediately below its origin to the base of its terminal filament (11th branch). The anterior two sub-branches of the first order are rather stout and dusky in their proximal parts and again carry a single series of finer sub-branches of second order along their anterior surface on their distal portion. In the following sub-branches of the first order these second-order sub-branches are reduced to traces or filaments, and the first-order sub-branches themselves become thinner and paler in order of their sequence distally, the last 4 being entirely filamentous and closely clustered.²⁹

The second (main) posterior branch of the barbel also carries a single series of 8 (or 7³⁰) sub-branches beginning immediately behind the origin of the first

²⁸ In the effort to achieve clarity, the insertions of the subbranches on the two main posterior branches have perhaps become spread out a slight bit more than they naturally are in the specimen and a slight distortion of the density of the entire system has thus resulted.

²⁹ See footnote concerning the figure.

³⁰ Dependent on whether the 7th sub-branch (in a count of 8) is regarded as a separate sub-branch of the first order, or as a second-order sub-branch originating



Figure 14. Barbel of *Linophryne arborifera eupogon* Regan and Trewavas. Drawn from type specimen by Y. H. Olsen.

posterior main branch of the barbel. The 3 anterior sub-branches on the second posterior main branch each give rise to a lateral pair of opposed filamentous sub-branches of the second order, the most anterior sub-branch also carrying a single median filament distally to the lateral pair. The more posterior sub-branches all branch in the median only, if at all. At the base of the last (8th or 7th) sub-branch (of the single anterior series), which is considerably enlarged and produced, with a long terminal filament, the stem of the second posterior main branch forms a knee in the hollow of which 3 pairs of filamentous sub-branches are inserted close together in a double row between the last single sub-branch and the base of the terminal filament, which is long (incomplete in the specimen) and irregularly branched and beset with a few minute bulb-bearing tentacles. The ends of all ultimate filaments are apparently more or less swollen when complete. Proximal portions of the lateral and of the two posterior main branches, with basal parts of the more anterior sub-branches of these, more or less dusky; basal peduncle of barbel black.

In the type specimen which now measures 29 mm. without caudal fin the length of the barbel from the anterior base of the peduncle to the knee (the base of the last sub-branch in the single series) of the second posterior main branch is 4.5 mm. or 15.5 per cent of the length of the fish. In the Atlantis collection from Station 1478, we also find another specimen, 26.5 mm. long without caudal fin in which the length of the barbel to the knee is only 3.5 mm. or 13.2 per cent. Although their difference in size is small, there is thus a not inconsiderable difference in the relative dimensions of the barbels in the two specimens pointing to a comparatively late but very rapid growth of this organ which might easily lead to the dimensions found in the much larger type of *L. arborifera arborifera* in which the length of the barbel, terminal filaments included, equals the length of the fish which is 50 mm. without caudal fin.³¹ This possibility gains further support from a comparison of the morphological development of the barbels in the two Bingham Collection specimens.

In the smaller one, collected at Atlantis station 1478, the first posterior main branch of the barbel carries only 3 small anterior, pale, branched, filamentous sub-branches followed by one transverse pair of filaments and the terminal filament of the branch itself, all occupying only the distal two-fifths of the stem of the branch, the proximal, dusky, three-fifths being as yet unbranched. On the second main posterior branch, the enlarged and produced sub-branch at the knee is only the sixth (instead of 8th as in the larger specimen) and last of the single anterior series. The barbels of the two specimens are otherwise identical. It thus appears that an increase in the number of sub-branches has also taken

from the anterior surface of the next following sub-branch of the first order near its base. The first interpretation seems the most natural one in the specimen on hand.

³¹ The lengths of the barbels, terminal filaments included so far as preserved, in the two specimens of the Bingham Collection are 27.5 and 38 per cent, respectively.

place between the sizes of 26.5 and 29 mm. without caudal fin, and if this increase is continued with further subdivisions and development of filaments to size 50 mm. without caudal, it is quite conceivable that the barbel found in the type of *L. arborifer arborifera* might result.

It is thus perfectly possible, or even probable, that further investigation may serve to confirm the identification of the type of *L. arborifera eupogon* first suggested by the writer, and in the meantime it would certainly seem unwarranted to give more than subspecific significance to the features shown by the smaller specimens.

***Linophryne coronata* Parr**

Linophryne coronata Parr 1927: Bull. Bingham Oceanogr. Coll. Vol. III, Art. 1, p. 13, fig. 4.

Linophryne longibarbata Borodin 1930: Proc. New England Zool. Club XI, p. 87.

Including the example obtained by the "Atlantis" at station 1478, three specimens are now on record which agree with the type of *L. coronata* in all general features of their bulbs and barbels and in the system and structure of the

Measurements of *Linophryne coronata* Parr

Subspecies	<i>longibarbata</i>	<i>coronata</i>	<i>diphlegma</i>
Length without caudal fin in mm.	75.5	33 ³²	33
Proportions in per cent of length without caudal:			
Length of caudal fin.	42	40	44
Length of maxillary.	53	38	51/54
Length of lower jaw.	56.3	39	51
Top of head before base of sphenotic spine to lower posterior corner of lower jaw ³³	59.5	50	60.6
Snout to posterior base of sphenotic spine.	29	29	28.8
Snout to eye.	24	18	21
Interorbital skeletal width.	10	12.5	13
External width between bases of sphenotic spines.	28	31	32
Snout to gill opening.	62	52	56
Diameter of eye.	3.3	3.6	4.5
Preopercular to sphenotic spine.	44	39.4	45.5
Angular to preopercular spine.	21	18.8	20
Longest lower fang.	18.2	9.4	21
Longest upper fang.	11.3	4.9	13
Total length of barbel.	187	90	276
Length of tassel.	28	11.5	9
Length of illicium stem.	17.5	10.0	22.7
Length of bulb.	9.5	9.1	10.6
Length of anterior terminal process on bulb.	8.8	7.0	18.0

³² The measurement previously recorded has reference to the point at which the thick black skin of the body changes abruptly into the pale caudal fin membrane.

³³ Angular spine not included.

branches and appendages on these parts, differing only in such details of secondary importance as mentioned in the key on page 44 and discussed and illustrated in the following. Since it is obviously possible, with so little material available, that these minor differences may subsequently be found to be only a matter of individual variations, and since the characters in question are under no circumstance of the order of importance of those on which our specific distinctions within the genus have otherwise been based (see page 42), the three specimens are here tentatively recorded as subspecies only, of *L. coronata*. As in the case of *L. arborifera*, the three "subspecies" have all been recorded from the same general region of occurrence, in this instance confined to the western North Atlantic only.

Terminal appendages on the bulb of the illicium composed of a stout bifid process anteriorly; followed by a pair of shorter, simple, thick, finger-like or tapering appendages; with a small, pointed, fin-like median process behind. Barbel slender, with a small tassel of minute branches at its distal end, but otherwise unbranched.

Tassel with a circle of four equal, small branches, at its base (proximal end), each with a uniserial row of stalked or sessile bulbs on one side, a simple or branched, minute appendage or filament on the other, and a simple terminal filament with swollen tip at the end (see figs. 15-20). Beyond these basal branches of the tassel the main stem of the barbel immediately branches once or twice, in a different manner in each subspecies.

***Linophryne coronata coronata* Parr**

Linophryne coronata Parr 1927: Bull. Bingham Oceanogr. Coll. Vol. III, Art. 1, p. 13, fig. 4. Regan and Trewavas 1932: Carlsberg Found. Oceanogr. Exp. 1928-30 Rep. No. 2, p. 110.



Figure 15. *Linophryne coronata coronata* Parr. Drawn by Y. H. Olsen.

This subspecies differs conspicuously from the other two subspecies by its relatively much shorter jaws and fangs as one may see from the measurements given on page 49 and from a comparison of the accompanying figure 15 with figures 17 and 19; the jaws being only about $2/5$, the longest lower fang $1/10$ and the longest upper fang $1/20$ of the length without caudal fin.

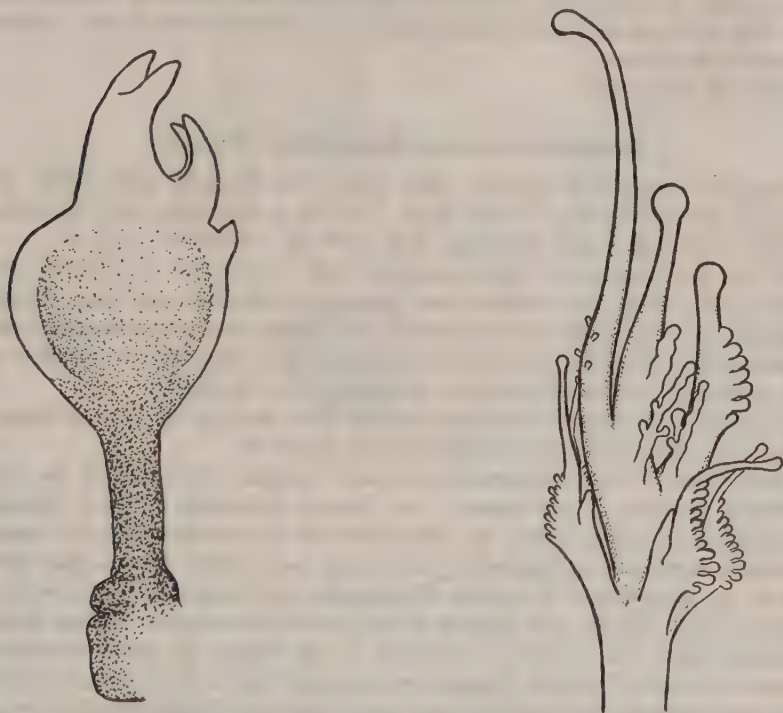


Figure 16. *Linophryne coronata coronata* Parr. Illicium left; tassel of barbel right. Drawn by author.

Beyond the ring of the four basal branches on the tassel, the main stem of the barbel immediately gives rise to two relatively short and thick branches in close succession (see figure 16) and ends in a somewhat longer, simple, terminal filament with a swollen tip. The first branch carries a small pair of rather irregular lateral appendages, with a minute median stalked tubercle between them, posteriorly at its base; a single series of 7 almost sessile small bulbs along its middle portion anteriorly; and a thick, swollen bulb at its end. The second branch also carries a pair of irregular appendages at its base, but anteriorly instead of posteriorly, and has a simple appendage farther up, but carries no

regular series of bulbs or tentacles. The second branch also ends in a greatly swollen tip. The terminal filament carries a few minute stalked tubercles on the proximal third of its length. Total length of barbel slightly less than the length of the fish without caudal fin.

The bulb of the illicium, exclusive of its distal appendages, is almost equal in length to the stem; the anterior process on the bulb is slightly shorter than the bulb itself and is divided distally for about one-third of its length. Distal processes all colorless.

Only the type known.

***Linophryne coronata longibarbata* (Borodin)**

Linophryne longibarbata Borodin 1930: Proc. New England Zool. Club. XI, p. 87; 1931, Bull. Mus. Comp. Zool., LXXII, p. 83; Regan and Trewavas 1932: Carlsberg Found. Oceanogr. Exp. 1928-30. Rept. No. 2, p. 107.

So far the structure of the appendages and branches on the illicium and barbel of this form have neither been figured nor described, nor has a general illustration of the species been published. To supply this want, the author has examined the type and prepared the accompanying diagrammatic figures of the specimen to which the following description may be added.

Length of jaws about $1/2$ or more; longest lower fang nearly $1/5$ and longest upper fang more than $1/10$ of length without caudal fin.

Main stem of barbel bifurcating opposite terminal filaments of the four proximal branches in the tassel. One branch trifurcates a short distance beyond the bifurcating point; the other gives rise to 3 sub-branches in a group around a terminal continuation of the branch itself, which latter again gives rise to an opposed pair of smaller sub-branches (trifurcates) from its proximal portion. The middle and longest of the three sub-branches arising simultaneously from the second main branch of the barbel, as above described, carries two series of minute filaments with swollen tips on its proximal portion, the other ultimate branches only one single series each beyond which they all end in a terminal filament with swollen tip. A short distance in advance of the tassel the barbel carries a soft, black outgrowth covered by normal skin. Total length of the barbel almost twice the length of the fish without caudal fin.

Bulb of illicium exclusive of distal appendages only slightly more than half the length of the stem; anterior process on bulb slightly shorter than bulb itself, divided almost to its middle. Undivided portion of anterior process and middle pair of terminal appendages, except along their posterior margins, black. Distal half of bulb, posterior fin-like process, posterior margins of paired appendages, and divided tips of anterior process white.

Only the type seen by the author. Second specimen recorded by Borodin (1931, p. 83) not available for examination.

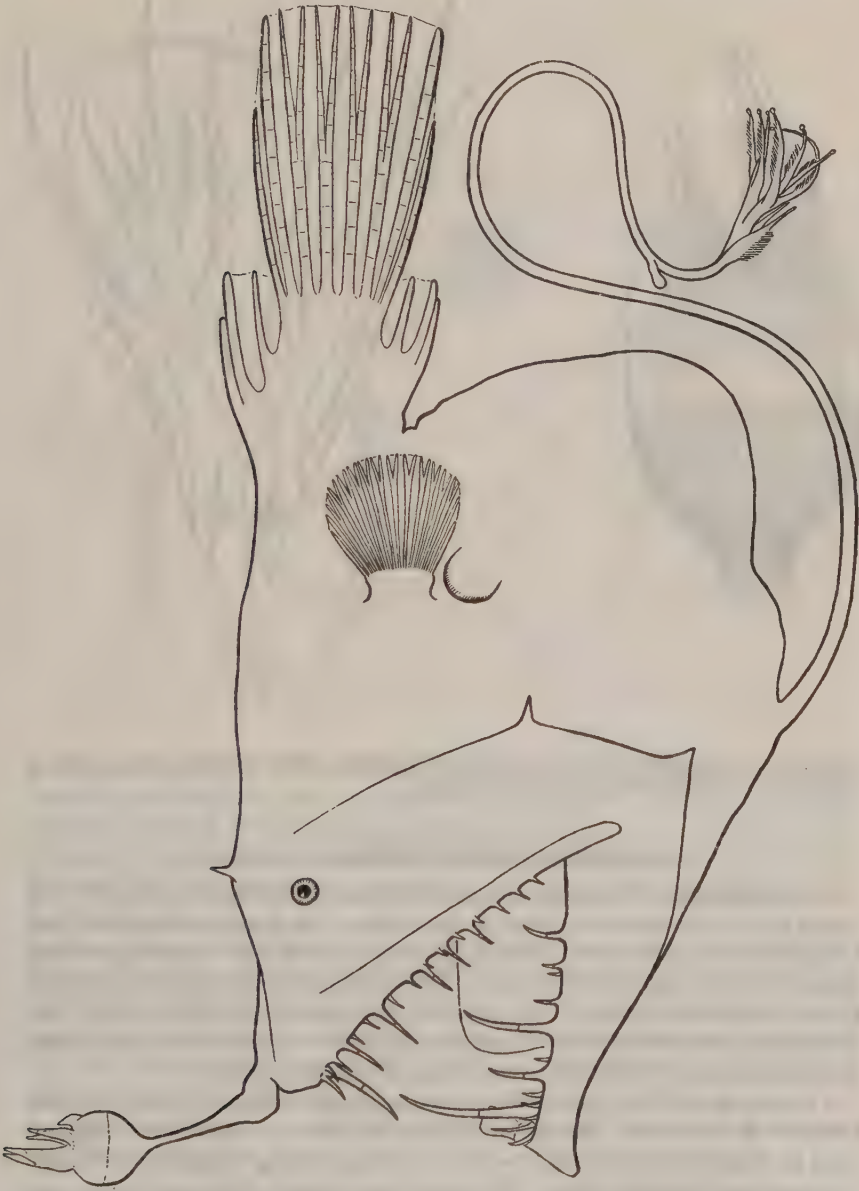


Figure 17. *Linophryne coronata longibarbata* Borodin. Drawn by author and Y. H. Olsen.

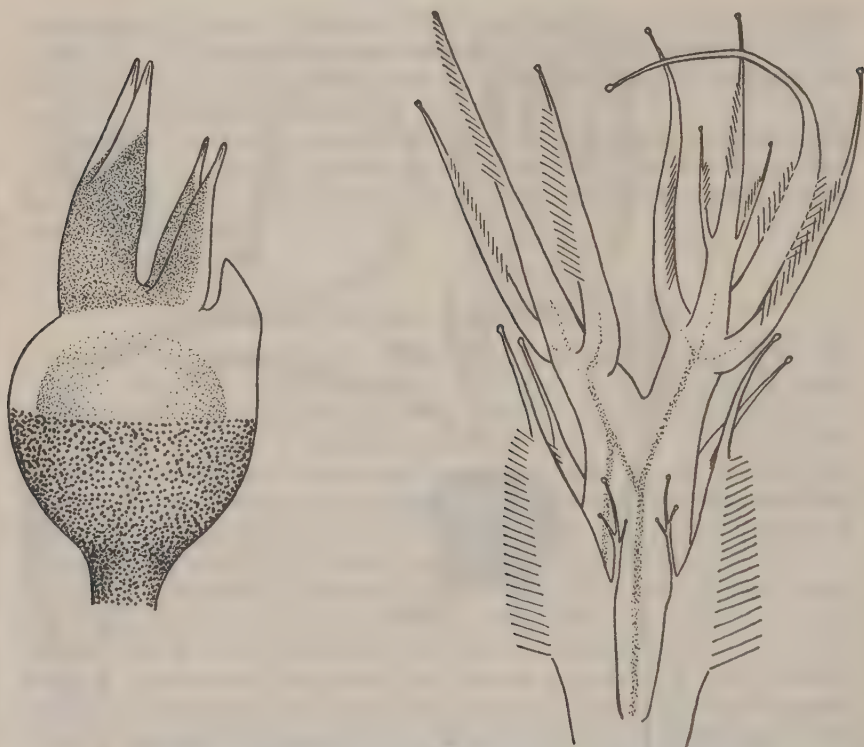


Figure 18. *Linophryne coronata longibarbata* Borodin. a. Bulb of illicium left; tassel of barbel right. Diagrammatic sketches by author.

***Linophryne coronata diphlegma* n. subsp.**

The proportions of the type specimen are given in the table on page 49. It agrees with *L. coronata longibarbata* in the length of the jaws and fangs; the jaws being about $1/2$, the longest lower fang about $1/5$, and the longest upper fang about $1/8$ of the length without caudal. It also agrees with subspecies *longibarbata* in the proportions between stem and bulb on illicium, but differs from both *longibarbata* and *coronata* in the extreme length of the barbel and in the length and appearance of the anterior terminal process on the illicium.

The main stem of the barbel bifurcates between the bases of the four proximal branches in the tassel. One main branch gives rise to a small lateral filament from its distal third and ends in a thick, fist-like swelling apparently distended by numerous internal bulbs. The other main branch bifurcates again, one of the sub-branches being simple with a short series of small sub-tentaculate

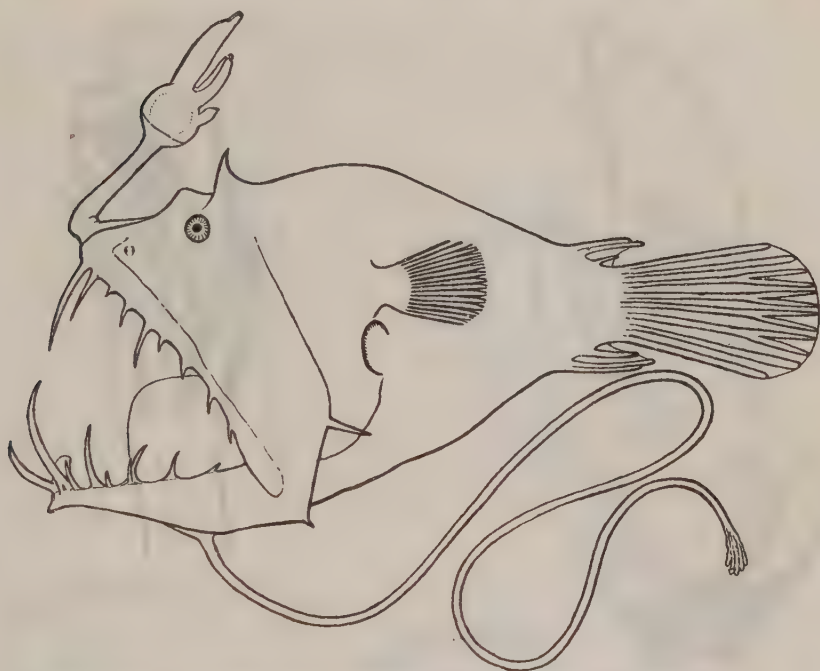


Figure 19. *Linophryne coronata diphlegma* n. subsp. Drawn by Y. H. Olsen.

bulbs and a terminal filament with swollen tip; the other sub-branch being twisted upon itself so that it is difficult to disentangle its profusion of long-stemmed bulbs or bulb-bearing filaments all arising from the same side, but whether in a single series or a more irregular arrangement is not clear. Some of these filaments appear to be branched at least once, with swellings at the end of each branch.

The anterior process on the bulb of the illicium is very long, about $1\frac{2}{3}$ times the length of the bulb itself, while its bifid tips are reduced to a pair of short protuberances only about $\frac{1}{7}$ of the length of the undivided portion, and well marked off from the latter in their outlines. The paired terminal appendages are also relatively elongate with distinctly mammilliform tips. Terminal appendages entirely colorless.

Only the type known. No. 3207 of the Bingham Oceanographic Collection. Atlantis station 1478.

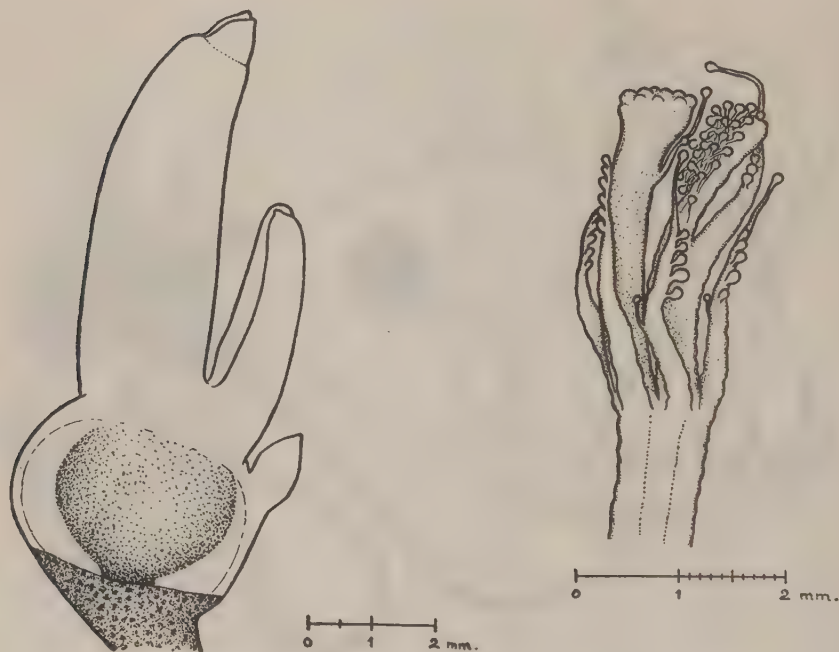


Figure 20. *Linophryne coronata diphlegma* n. subsp. Bulb of illicium left; tassel of barbel right. Drawn by author.

GENUS **BOROPHRYNE** Regan

Borophryne masculina n. sp.

D. 3. A. 3. P. 16. C. 2 + 4 + 2. Head in the shape of an oblique pyramid resting on its smallest side, the tip of the lower jaw forming its apex. A tooth-bearing rostral prominence above and in front of the upper jaws which are toothless. The lower jaw projects forward of the upper and of the rostral prominence. Nasal region somewhat swollen. Anterior nostril only about half the diameter of the posterior nostril, which is large and situated close to the eye. Eyes fairly large, lateral, directed outward, not telescopic. A long, slender supraorbital (sphenotic?) spine directed outwards at right angle above and behind each eye. Lateral line organs on short pigmented tags connected by thin white lines. Dorsal and anal fin rays projecting through the skin with their tips, only, near the base of the caudal fin far behind their own fin bases.

In all of the characters mentioned in the preceding the specimen agrees perfectly with the descriptions and figures given by Regan and Trewavas (1932, Carlsberg Found. Oceanogr. Exp. 1928-30. Rep. No. 2, p. 18, figs. 7



Figure 21. *Borophryne masculina* n. sp. Lateral view above; dorsal view of head at lower left; frontal view of head at lower right. Drawings by Y. H. Olsen.

and 8, and p. 106) of the two males found attached to two female representatives of the genus *Borophryne*, and it is thus for the first time possible to introduce a new Ceratioid species referred to its proper genus on the basis of a still unattached male only. The characters on which the specific distinction of *B. masculina* from *B. apogon* is based all have reference to minor details, only, and do not involve any differences which would even approach to generic significance. It is, on the contrary, not entirely without hesitation that the new form has been given the rank of a separate species rather than that of a subspecies only. The differences are certainly not greater or more significant than the differences between the two males referred by Regan and Trewavas to a single species on the basis of their identification of the females to which the males were attached. At this point, however, the author would like to raise the question as to whether the identification of two similar-looking females is at all justified in the face of such conspicuous differences in the males. The features of one sex must certainly, until otherwise proven, be considered to be equally as important as the features of the other sex, and it hardly seems reasonable to regard as specifically identical one completely pigmented and one entirely unpigmented male which also show differences in other respects.³⁴

Borophryne masculina differs from both of the male specimens referred by Regan and Trewavas to *B. apogon* by having only 3 rostral denticles, instead of 5. It differs further from the pigmented form in having the ends of 3 dorsal and 3 anal rays projecting freely through the skin at the base of caudal fin; and from the unpigmented form by being completely pigmented and by the fact that the base of dorsal fin is well behind the base of anal, the dorsal fin rays being correspondingly shorter.

Lower jaw with 4 small teeth on each side near the median in which a small single tooth projects forward. Three rostral denticles, one median and one on each side. Eight nasal lamellae. Nasal cover unpigmented except along its base and around the rim of the posterior nostril. Nape high and somewhat sharp behind the skull, probably supported by spinous processes. Lateral line system complete on head, incomplete on body (see figure 21). Body somewhat compressed.

The type specimen is a male measuring 24 (16 + 8) mm. The distance from the tip of the rostrum to the gill openings equals about 45 per cent of the length

³⁴ In the pigmented male Regan and Trewavas mention 2 dorsal and 2 anal rays projecting with their ends through the skin at the caudal base. In the unpigmented male 3 dorsal and 3 anal rays are recorded, and it seems indicated in the illustration that all three rays of each fin must project. There thus appears to be an actual difference between the two specimens with respect to the number of rays projecting from the skin, and it is also probable that only two rays altogether in each fin may be found upon dissection of the pigmented male. Regan and Trewavas (loc. cit., p. 19) also mention differences between the two specimens in regard to the projection of the lower jaw.

without caudal fin, the greatest width of the head exclusive of the sphenotic spines about 35 per cent, the greatest depth about 37 per cent, the diameter of the eyes 7.5 to 8 per cent, the length of lower jaw 21.5 per cent, and the distance from the tip of the rostrum to the eyes about 13 per cent. Other proportions as shown in the illustration, which is based upon camera lucida drawings except in regard to the caudal and pectoral fins which are curled up in the specimen.

Entire specimen, including caudal and pectoral fin rays black, with the exception of the nasal cover only (see above).

Type specimen No. 3208 of the Bingham Oceanographic Collection. Atlantis station 1478.

apparently cosmopolitan bathypelagic form, has been reported identical with an Indo-Pacific species, and only three (one of which is the bathypelagic species mentioned above) range to the Eastern Atlantic. More detailed generalization of the relations of the American Atlantic and Pacific faunas to one another and to those of other parts of the world is for the present dangerous. The extraordinary richness in peneids of the tropical west coast of America has not been realized in the past: eleven new American species are described below, of which ten are from the Pacific; three heretofore undiscovered Pacific species indistinguishable from Atlantic forms are also recorded. One of the new Pacific species requires a new genus for its reception; two genera, *Trachypeneus* and *Parapeneopsis*, the former not known to exist on the western coast, the latter not known to occur in America, are shown to be represented by three and by one species respectively; the number of species of the genus *Eusicyonia* known from Pacific America is increased from three to nine. The littoral sergestid *Acetes*, not heretofore known from western America, is found to be represented by an undescribed species. In such circumstances, successful consideration of the complex problems of distribution and affinity of the faunas of the two American coasts and their relations to the peneids of the remainder of the world is contingent upon further study. Since it has become evident in the course of the work that purely systematic knowledge of the peneids of other regions which might have been supposed better known was to some extent inadequate, and that even the larger groupings, genera and subfamilies, required fresh consideration, a monographic approach to the peneids is probably desirable. Toward this the present and the preceding paper, and further studies now in preparation, may be regarded as contributions of material.

LIST OF NEW GENERA, SUBGENERA, SPECIES AND SUBSPECIES

Protrachypene, n. gen.

Trachypeneopsis, n. gen.

Trachysalambria, n. subgen.

Penaeopsis (*Metapenaeopsis*) *mineri* n. sp.

Protrachypene precipua, n. gen. and sp.

Trachypeneus (*Trachysalambria*) *similis pacificus*, n. subsp.

Trachypeneus (*Trachysalambria*) *byrdi*, n. sp.

Trachypeneus (*Trachysalambria*) *brevisuturæ*, n. sp.

Parapeneopsis balli, n. sp.

Eusicyonia parri, n. sp.

Eusicyonia disparri, n. sp.

Eusicyonia disedwardsi, n. sp.

Eusicyonia aliaffinis, n. sp.

Eusicyonia disdorsalis, n. sp.

Acetes americanus limonensis, n. subsp.

Acetes binghami, n. sp.

ACKNOWLEDGEMENTS

The material upon which this paper is based is chiefly contained in the Bingham Oceanographic Collection. It is derived from invertebrate collections made under the direction of Mr. Harry Payne Bingham during the first and third, Atlantic American, and second, Pacific American, Oceanographic Expeditions of the "Pawnee" in 1925, 1926, and 1927; from an Indopacific collection gathered by Mr. Richard Colestock in the markets of various Oriental seaports during the first months of 1933; from collections obtained in the market of Panama City during December, 1933, by Mr. Junius Byrd; from collections made in the Bay of Panama and at Colon during February, 1934, by Professor A. E. Parr and M. D. Burkenroad; and from material collected by Mr. Marshall Bishop.

Some undescribed material in the collection of the Zoology Department of the Peabody Museum at Yale, especially that obtained on the west coast of Central America by Mr. F. H. Bradley in 1866, has been available, as have the peneid collections of the American Museum of Natural History. The examination of a number of specimens has been permitted by the Museum of Comparative Zoology at Harvard; and of an example of the new genus *Trachypeneopsis* by the Rijks Museum van Natuurlijke Historie of Leiden. To the authorities of these institutions I wish to acknowledge my deep indebtedness. Especially am I grateful to Dr. R. W. Miner and Dr. W. G. Van Name of the American Museum of Natural History, who generously provided facilities for a portion of the work. To Mr. Colestock, to Mr. Byrd, to Mr. Bishop, and to Mr. James Zetek I wish to express my

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SYSTEMATIC ACCOUNT

PENAEIDAE Bate

PENAEINAE Burkenroad, 1934

PENAEOPSIS Bate, restricted

Penaeopsis, BATE (A. Milne Edwards MS), 1881; A. MILNE EDWARDS and BOUVIER, 1909, part; DE MAN, 1911, part; SCHMITT 1926a, part. *Parapenaeus*, SMITH, 1886, part; DE MAN, 1911, part; BALSS, 1925, part. *Metapenaeus*, WOOD MASON and ALCOCK, 1891, part; ALCOCK, 1905 and 1906, part.

Metapenaeopsis, BOUVIER, 1905a.

Archipenaeopsis, BOUVIER, 1905b.

Leptopenaeus, KISHINOUE, 1929.

Ceratopenaeus, KISHINOUE, 1929.

Erythropenaeus, KISHINOUE, 1929.

Not *Penaeopsis*, FAXON, 1895.

The generic titles *Penaeopsis* and *Metapenaeus* have been regarded as synonymous by most authors since Milne Edwards and Bouvier, 1909, and have been at all times so defined as to include identical groups of species. The limits of the genus in this usual unrestricted sense, have been considered as set by the presence of a pleurobranch on XIII but not on XIV, the absence of longitudinal and transverse sutures from the carapace, and the presence of exopodites on most of the walking legs. These characters have been attributed to over sixty species, but as will be shown below, not only do certain species included in the "genus" fail to conform to the above definition, but the other, conformable, species do not constitute a homogeneous group and cannot be maintained as a single genus.

The genus *Penaeopsis* in the unrestricted sense in which it has been employed by preceding workers usually has been subdivided into two groups: those species lacking, and those possessing marginal spines on the telson. Unfortunately this division obscures natural relationships, and has given rise to much confusion. Most, and probably all, of the species, "Group I," described as lacking the marginal armature, actually possess it. Thus De Man, 1924, has noted the presence of minute mobile lateral spines, previously overlooked, in *P. brevicornis* (H. M. Edwards) and *P. lysianassa* (De Man) of "Group I," and a similar

armature is present in *P. affinis* (H. M. Edwards), *P. monoceros* (Fabricius) and *P. joyneri* (Miers), in which it has been stated to be absent. Conversely, *P. cognatus* Nobili; *P. stebbingi* Nobili; the superspecies comprising *P. ensis* (deHaan), *P. intermedius* (Kishinouye), *P. intermedius anchista* De Man and *P. endeavouri* Schmitt, all of which have been placed in "Group II" among the species, chiefly with asymmetrical petasma, possessing marginal spines, are very closely related to the species of "Group I," rather than to the other species of "Group II." Two of the species which have been included in "Group II," *Penaeus richtersii* Miers (*Penaeopsis*, De Man, 1911) and *Metapeneus mobilispinis* Rathbun, lack the pleurobranch of somite XIII and bear only a remote relationship to any of the other species of the "genus."

Of other efforts at subdivision of *Penaeopsis*, Schmitt, 1926a, although adhering to the usual separation by presence or absence of telson armature, suggests that a group of species consisting of *P. serratus* A. Milne Edwards, *P. rectacutus* (Bate), *P. coniger* (Wood Mason and Alcock), and *P. coniger* var. *andamensis* (Wood Mason and Alcock), might be separated from the remainder of the genus by the following characters:

INNER ANTENNULAR FLAGELLUM OF THE MALE WITH THE BASAL PORTION SET OFF BY A MORE DISTAL KNOB OR DENTICLE, FLAGELLA OF BOTH SEXES AS LONG AS OR LONGER THAN THE PEDUNCLE; SHORT SCALE-LIKE EXOPODS, EXCEPT IN *P. CONIGER ANDAMENSIS*; TELSON ARMED WITH TWO OR THREE PAIRS OF MOVABLE SPINES IN ADDITION TO A DISTAL, IMMOVABLE PAIR; BRANCHIAL FORMULA OF THE EIGHTH SOMITE POSSIBLY DIFFERENT FROM THAT OF THE "METAPENEI" IN THAT THE ANTERIOR GILL IS PERHAPS A PLEUROBRANCH RATHER THAN AN ARTHROBRANCH. We may note that *P. coniger* and *P. coniger andamensis* possess, in common with many of the species which Schmitt lumps as "Metapenei," an asymmetrical petasma; while the petasma of *P. serratus* and *P. rectacutus* is symmetrical. There is no real difference in homology of the anterior dorsal gill of the eighth somite between any Penaeidae, although the gill has been variously termed both arthrobranch and pleurobranch. The difference in length of antennular flagellum and its nature in the male between *P. coniger* and *P. coniger andamensis*, and the other species with asymmetrical petasma seems rather to point a near relationship of *P. serratus* and *P. rectacutus* to all of "asymmetrica" than to distinguish the four species selected by Schmitt as more closely related to one another than to the second group, evidently regarded by Schmitt as homogeneous, composed of the remainder of the species with asymmetrical petasma; *P. affinis* (H. M. Edwards) and its allies; and the two species which lack the pleurobranch of XIII. For these and other reasons it may be said that Schmitt, on the basis of insufficiently diagnostic characters, has suggested a grouping of the species of "*Penaeopsis*" which fails to coincide with natural boundaries.

Kishinouye, 1929, has proposed the separation of species with asymmetrical petasma from the remainder of the "genus," a division with disadvantages similar to but less obvious than those inherent in Schmitt's grouping. The

differentiating characters employed by Kishinouye are: PETASMA ASYMMETRICAL, ENDOPOD OF FIRST MAXILLA UNISEGMENTED, AN EXOPOD ON THE FIFTH LEGS, AND THE RECEPTACULUM SEMINIS SEPARATED INTO TWO DISTINCT SACS. Kishinouye divides his group into the three genera *Leptopenaeus*, *Ceratopenaeus*, and *Erithro-penaeus*. However, although these three series of species form, as pointed out by Kishinouye, "a quite natural assemblage," and one well distinguished from *Penaeopsis monoceros* and its allies, their distinction from *Penaeopsis serratus* and related species with symmetrical petasma, which Kishinouye's method of division lumps with *P. monoceros* and with *P. richtersii*, is not discussed. As to the differentiating characters employed, the sperm receptacles of American species with asymmetrical petasma do not include the pair of sac-like enlargements to which Kishinouye refers, while those of *P. serratus* and its allies do include such structures. The nature of the endopod of the first maxilla, whether or how "segmented," is a character of considerable value, but one not substantiating Kishinouye's concepts. The maxillary palp in all Penaeinae which I have examined is composed of a single segment; its distal portion may, however, be produced as a more or less constricted lobe of variable length, which when long is separated from the basal portion by an area of folding, and may be further divided by more or less marked constrictions at which folding occurs. These subdivisions are almost certainly not distinct articles separated by true joints. In Kishinouye's three genera of "asymmetrica," the palp is short and its distal end is unproduced, while in the *P. monoceros* and *P. richtersii* groups there is a distal lobe; but since the maxillula of *P. serratus*, with symmetrical petasma, is of the same form as in the asymmetrica, the character does not possess the diagnostic value ascribed to it by Kishinouye. Finally, the three genera into which Kishinouye divides the species with asymmetrical petasma, although they appear to be natural superspecific groups, seem to form no more than one section of "asymmetrica," the American species forming a section equivalent in importance, by Kishinouye's characters, to one composed of all three Indo-pacific groups.

The names *Metapenaeopsis* and *Archipenaeopsis* created and later retracted by Bouvier were based upon misinterpretations of the branchiae. It is unfortunately necessary to define and utilize in a subgeneric sense the former of these names, as indicated in a succeeding paragraph.

The species which have been included under *Penaeopsis* form three major groups which are clearly of generic importance. The smallest of these three groups, to which reference has been made (Burkenroad, 1934) as "the first of three genera confused under the name '*Penaeopsis*'," is composed of *P. richtersii* and *P. mobilispinis*. It resembles the other two genera only superficially, the pleurobranch of somite XIII being absent as in *Trachypeneus* and related genera. This group therefore needs no further consideration in connection with the revision of *Penaeopsis*; its distinctive features will be discussed on a later page as those of *Trachypeneopsis*, new genus. *P. serratus* and *P. rectacutus*

of Schmitt's subgroup *Penaeopsis* of the unrestricted genus; together with the species of the three genera proposed by Kishinouye (which number among them members of both of Schmitt's subgroups), make up the genus *Penaeopsis* in a restricted sense by virtue of including Milne Edwards's generic type, *P. serratus*. To this numerous group of species, reference has been made in the preceding paper as "the third of three genera confused under the name '*Penaeopsis*'." Since the type of Wood Mason's genus *Metapenaeus* is a species belonging to a different generic group than does the type of *Penaeopsis* Bate, *Metapenaeus* may be revived in a restricted sense for the species related to *P. monoceros* and *P. affinis*, which have been mentioned in the preceding paper as forming "the second of three genera confused under the name '*Penaeopsis*'."

METAPENAEUS Wood Mason and Alcock, restricted

Basal segment of antennular peduncle without a spine on its median border. Maxillary palp with a produced, constricted distal portion. Petasma with a pair of channeled, spout-like distolateral projections; without distoventral projections. Anteroventral angle of the carapace without a pterygostomial or branchiostegal spine. Telson armed with a series of mobile lateral spines of variable size; no fixed lateral spines. Anterior pereopods with, fifth pair without an exopodite. Basis of third chelipeds usually (probably always) armed. Somite XIII with a pleurobranch. Carapace without longitudinal and transverse sutures.

Known species confined to the Indopacific (save for certain migrants into the Mediterranean through the Suez Canal). Type, *Metapenaeus affinis* (H. Milne Edwards). Named species: *M. affinis* H. M. Edwards, *mutatus* Lanchester, *monoceros* Fabricius, *elegans* De Man, *incisipes* Bate, *deschampsii* Nobili, *cognatus* Nobili, *spinulicauda* Stebbing. *M. stebbingi* Nobili. *M. dobsoni* Miers, *joyneri* Miers, *brevicornis* H. M. Edwards, *lyssianassa* De Man. *M. macleayi* Haswell, *demani* Roux. *M. ensis* De Haan, *intermedius* Kishinouye, *intermedius anchista* De Man, *endeavouri* Schmitt.

PENAEOPSIS Bate, restricted

Basal segment of antennular peduncle with a spine on its median border. Maxillary palp without a produced distal portion. Petasma without deeply channeled spout-like distolateral projections. Anteroventral angle of the carapace with a pterygostomial spine. Telson armed with a pair of fixed lateral spines behind a series of mobile ones. All pereopods with exopodites of more than vestigial nature. Basis of third chelipeds never armed. Somite XIII with a pleurobranch. Carapace without longitudinal or transverse sutures.

Distribution cosmopolitan. Type, *Penaeopsis megalops* (Smith) (*P. serratus* Milne Edwards and Bouvier, 1909; not *Penaeus serratus* Bate, 1881). Species falling into two subgenera as follows:

- I. *Penaeopsis* Bate, sensu stricto. Petasma symmetrical. Vestigial anterior arthrobranch of somite XIII absent. Named species: *P. megalops* Smith, *serratus* Bate, *rectacutus* Bate.
- II. *Metapenaeopsis* Bouvier, 1905a, redefined. Petasma asymmetrical. Vestigial anterior arthrobranch of somite XIII present [save in *P. lamellatus* (De Haan) according to Schmitt, 1926a]. Type, *Penaeopsis* (*Metapenaeopsis*) *pubescens* (Bouvier). Species divisible into two sections, as follows:

SECTION 1. External piece (distoventral projection) of the left petasomal endopod reduced to a rudiment. Known distribution limited to the Atlantic and the American Pacific. Species: *P. goodei* Smith, *smithi* Schmitt, *kishinouyei* Rathbun, *mineri*, n. sp., and *pubescens* Bouvier.

SECTION 2. Distolateral projection of the left petasomal endopod as large as or larger than the right one. Known distribution limited to the Indopacific. Species grouped by Kishinouye, 1929, as follows: (Leptopenaeus) *P. philippii* Bate [with which *P. coniger andamensis* (Wood Mason and Alcock) and *P. philippinensis* (Bate) are synonymous, Calman, 1923], *coniger* Wood Mason and Alcock, *sibogae* De Man, *distinctus* De Man. (Ceratopenaeus) *P. dalei* Rathbun, *mogiensis* Rathbun (with which *P. hilarulus* De Man is synonymous, Schmitt, 1926a), *lamellatus* De Haan, *borradalei* De Man. (Erythropenaeus) *P. acclivis* Rathbun, *barbatus* De Haan (with which *P. akayebi* Rathbun is synonymous, De Man, 1911). Other named Indopacific species probably of the section are: *P. assimilis* De Man, *batei* Miers, *commensalis* Borradaile, *consobrinus* Nobili, *evermanni* Rathbun, *gallensis* Pearson, *gracilis* Dana, *longipes* Paulson, *novae-guineae* Haswell [with which *P. stridulans* (Alcock) is synonymous, Schmitt, 1926a], *perlaram* Nobili, *quinquedentatus* De Man, *vaillanti* Nobili, *velutinus* Dana.

In the preceding paper (1934), the genera of Penaeinae have been arranged in four supergeneric series or maniples centering about *Penaeus* Fabricius, *Parapenaeus* Smith, *Trachypeneus* Alcock, and *Macropetasma* Stebbing. *Penaeopsis* Bate as here restricted was referred to the **Parapenaeus** series; *Metapenaeus* Wood Mason and Alcock as here reestablished, to the **Trachypeneus** series. Since these two genera are members of different maniples, a number of characters common to all other members of either supergeneric group are diagnostic for *Metapenaeus* and *Penaeopsis* with reference to each other, and have therefore been included in the generic definitions employed in the foregoing revision. The distribution of these characters of more than generic significance among the Penaeidae is as follows:

The PARAPENAEID SPINE of the distomedian region of the basal article of the

antennular peduncle appears to be present in premysis or mysis stages of all Penaeidae. The spine occurs in postmysis stages of Penaeinae and some Aristaeinae, but it persists to maturity in *Penaeopsis*, *Parapenaeus* and *Artemesia* alone of the Penaeidae which I have examined.

The ultimate pair of lateral teeth of the telson are fixed in the adults of Solenocerinae (possibly in a few Aristaeinae) and Eusicyoninae, in which they are usually not preceded by mobile lateral spines; and in *Penaeopsis*, *Parapenaeus*, and *Artemesia* alone of Penaeinae, in which they are preceded by mobile spines. There is never more than one pair of fixed lateral teeth, which appear to be derived from a mobile larval pair usually longer than the rest and fourth from the base of the telson, and which may survive as a pair of mobile spines, unchanged, in the adult of other forms.

A constricted, produced distal portion is present on the maxillary palp of *Solenocera*, where it is short and not well separated; in *Funchalia* and *Penaeus*, where it is elongate and constricted at several points; in *Trachypeneus*, *Xiphopeneus*, *Parapeneopsis*, where it is often extremely short and scarcely separated by a fold or constriction from the basal portion; and in *Metapenaeus* where it is of medium length and well separated. On the contrary, a lobe is completely absent in *Penaeopsis*, *Parapenaeus*, and *Artemesia*, and in the Eusicyoninae.

In the petasma of *Metapenaeus*, as in the **Trachypeneus** series, there is a pair of deeply channeled distolateral projections and no pair of distoventral projections. On the contrary, in the petasma of *Parapenaeus* and *Artemesia* and in modified but recognizable form in the subgenus *Metapeneopsis* of *Penaeopsis*, there is a pair of distoventral projections in addition to a latero-distal pair which is only slightly or not at all channeled. This type of petasma also characterizes *Macropetasma* and the Eusicyoninae. The petasma of the subgenus *Penaeopsis* is anomalous, being of the open, simple form found in Aristaeinae, Solenocerinae, and the **Penaeus** series of Penaeinae, in which, contrary to *Penaeopsis*, it is usually correlated with an unenclosed sperm receptacle.

By the points mentioned above, *Metapenaeus* seems clearly distinct from *Penaeopsis* in characters which, by their correlated presence or absence over a wide range of Penaeinae may be taken to be of considerable importance. However, in one character otherwise of considerable significance—the presence of a pleurobranch on somite XIII—*Metapenaeus* resembles the **Parapenaeus** series including *Penaeopsis*, and differs from the entire **Trachypeneus** series.

In two characters of less general significance, *Metapenaeus* is clearly set off from *Penaeopsis*: The exopodite of its fifth leg only is absent; and the basis of its third chelipeds is armed with a spine. In the first of these characters *Metapenaeus* differs from almost all other Penaeinae (the loss being paralleled in one species of *Penaeus*) so that the distinction, while convenient, because of its uniqueness cannot be evaluated as an indicator of affinity. The second

character may perhaps strengthen the evidence for relationship between *Metapenaeus* and the *Trachypenaeus* series, since an armature of the third leg basis seems otherwise to occur among Penaeidae only in certain forms related to *Trachypeneus*, as *Atypopenaeus*.

In a number of characters which seem of little significance for the elucidation of phylogenetic relationship, *Metapenaeus* and *Penaeopsis* resemble one another. Thus the vestigial anterior arthrobranch of somite XIII is present in *Metapenaeus*, most of the species of the subgenus *Metapenaeopsis* of *Penaeopsis*, and in species of *Trachypeneus* and related genera; while it is absent in other species of *Trachypeneus* and in the subgenus *Penaeopsis* and in *Parapenaeus*. The branchial lamella of somite VII is filamentose in *Metapenaeus*, *Penaeopsis*, *Artemesia* and those species of the **Trachypeneus** series available to me; while it is bare of filaments in *Parapenaeus*. The thelycum of both *Metapenaeus* and *Penaeopsis* is of the enclosed type found in Eusicyoninae and in all Penaeinae except certain members of the **Penaeus** series and *Macropetasma*, the sperm receptacles being formed by cavities of a deep, essentially transverse depression of the anterior part of sternite XIV. In *Metapenaeus* and in the American species of *Metapenaeopsis*, no portion of this depression is especially expanded; the spermatophores enter each lateral half of the groove by median openings, the sperm being extruded at the lateral, anterior ends of the groove. In the subgenus *Penaeopsis*, as in *Parapenaeus*, a portion of the groove on either side is deeply invaginated to form a pair of large membranous sacs in which the spermatophores are deposited, and entrance and exit of the receptacles are not distinctly separated. Receptacles somewhat similar to both types are found among *Trachypeneus* and other genera of that series, and a receptacle almost identical with that of the subgenus *Penaeopsis* occurs in Eusicyoninae. Longitudinal and transverse sutures of the carapace are limited, within the Penaeidae, to members of the *Trachypeneus* and *Parapenaeus* series. Within the former group the structures appear in all possible degrees of development and combination, either, neither, or both being present; within the latter group, the sutures are present in *Parapenaeus*, absent in *Artemesia*. Thus, it does not seem necessary to assume that the absence of the sutures both in *Metapenaeus* and *Penaeopsis* implies a near degree of relationship. Finally, it may be mentioned that in the American species of the subgenus *Metapenaeopsis* of *Penaeopsis* and in the American section of Division I of *Trachypeneus* the basis of the third maxillipedes is armed with a spine, a condition which has not been described for other Penaeidae. It is very doubtful that this interserial resemblance is fraught with any phylogenetic significance.

The evidence detailed above seems to justify the conclusion that of the species formerly included under the name *Penaeopsis*, those here referred to *Metapenaeus* are more closely related to *Trachypeneus*, those here referred to *Penaeopsis* more closely related to *Parapenaeus*, than is either group of species to the other.

Metapenaeus stands apart from the otherwise very compact *Trachypeneus* series, particularly in the presence of a pleurobranch on somite XIII and the absence of an exopodite from the fifth leg. *Penaeopsis*, on the other hand, is only slightly distinguished from *Parapenaeus*, aside from the absence of longitudinal and transverse sutures, by the filamentose branchial lamella of its seventh somite; the presence of more than one pair of mobile lateral spines preceding the fixed pair of the telson; the less reduced exopodites of the walking legs; and the presence of a petasma either asymmetrical, or open and lacking produced distolateral and distoventral projections.

Since several distinctions between the two subgenera of *Penaeopsis* have been pointed out, it may be of value to call attention to some of the numerous minor resemblances, in addition to those mentioned by Schmitt, 1926a, as common to *P. serratus* and *P. coniger*, between *Penaeopsis* and those members of *Metapenaeopsis* which formed Kishinouye's "genus" *Leptopenaeus*. The orbital angle is undentiform in the subgenus *Penaeopsis* and in the *P. coniger* group, dentiform in the remainder of "asymmetrica." The basis of the second chelipeds is unarmed in the *P. coniger* group, as is usual in *Penaeopsis* but unusual among the remaining species of *Metapenaeopsis*. The mobile lateral spines of the telson are not compactly grouped in *P. coniger* and related species, more as in *Penaeopsis* than as in the other species of *Metapenaeopsis*. The paired spines of the posterior margin of sternite XI, very weakly indicated in the *P. serratus* group, are in the *P. philippii* group weaker than is usually the case in "asymmetrica" (it may be noted that some indication of paired posterior projections of sternite XI, and sometimes of IX, X, and of the three posterior sternites as well, are present in all Penaeidae; they are particularly well developed on X and XI in Eusicyoninae). It can hardly be doubted that the *P. coniger* group is congeneric with the other species with the distinctive asymmetrical petasma. Therefore, although it might be possible to regard *Penaeopsis* as sufficiently distinct from *Metapenaeopsis* to stand as a separate genus, in view of the very close relationship presaged by the numerous minor resemblances between the two groups, it seems advisable to regard them as forming a single genus.

Since previous descriptions and figures of *Artemesia*, the third genus of the *Parapenaeus* series, are in many respects inaccurate, and since the form has been previously regarded (Bouvier, 1908; Balss, 1925) as a peculiar one occupying an isolated position, brief mention in this place of the characters in which it resembles and by which it is distinguished from *Penaeopsis* and *Parapenaeus* may be desirable. Through the kindness of the Museum of Comparative Zoology at Harvard I have been enabled to examine a male and three females of *A. longinaris* Bate, reported by Milne Edwards and Bouvier, 1909.

Artemesia displays a very strongly developed parapeneid spine; a distal pair of lateral telson spines completely fused to the body of the telson (although the line of juncture remains clearly visible); a pleurobranch on somite XIII but

not on XIV; a thelycum which externally very closely resembles that of *Parapenaeus*, the subgenus *Penaeopsis*, and the Eusicyoninae, and which almost certainly includes a pair of invaginated sac-like sperm receptacles as in those forms; a maxillulary palp which lacks a produced distal portion; and a petasma (quite incorrectly figured by Bouvier) which repeats part for part including the posterodistal spine and lamella the structures found in *Parapenaeus longirostris*, although the lamella mediad the base of the distolateral spine on either side is produced to form a shallowly channeled rigid spout-like projection. These characters definitely place it with the **Parapenaeus** series.

Artemesia differs from *Parapenaeus* and *Penaeopsis*, and indeed, from all other Penaeinae and Eusicyoninae, by the presence of a small but filamentose anterior arthrobranch on XIII, a character otherwise found only in Aristaeinae and Solenocerinae. *Artemesia* is further excepted from the parapenaeine mode by lacking a branchiostegal or pterygostomial spine, a condition which however occurs even in one species of *Parapenaeus*. In the complete loss of exopodites except that of IX and perhaps in the loss of leg-base armature, it seems to represent one extreme of the reduction series formed by *Metapenaeopsis*—*Penaeopsis*—*Parapenaeus*. In the presence of filaments on the branchial lamella of VIII and the complete absence of longitudinal and transverse sutures, it agrees with the genus *Penaeopsis*. Its maxillulary palp lacks the conspicuous spine or spines of the median projection present in other peneids.

SUBGENUS **PENAEOPSIS** Bate, sensu stricto

Penaeopsis megalops (Smith)

Figure 1, page 20.

Parapenaeus megalops SMITH, 1886; ALCOCK, 1906.

Penaeopsis serratus BATE (A. Milne Edwards MS), 1881.

Artemesia talismani BOUVIER, 1905a.

Penaeopsis serratus MILNE EDWARDS and BOUVIER, 1909; DE MAN, 1911; BALSS, 1925; SCHMITT, 1926a; BOONE, 1927, part.

Parapenaeus paradoxus (Bouvier) BOONE, 1927, part.

Not *Penaeus serratus* BATE, 1881.

19 adult, 7 juvenile males, carapace length 10 to 20 mm; 13 adult, 1 juvenile female, carapace length 10 to 24.5 mm. *B.O.C.* 35. North of Glover Reef, Gulf of Honduras, 366 fathoms, May 20, 1925.

8 adult, 3 juvenile males, carapace 10 to 17 mm; 29 adult, 5 juvenile females, carapace 12 to 22 mm. *B.O.C.* 36. North of Glover Reef, Gulf of Honduras, 434 fathoms, April 20, 1925.

In naming his Indopacific species as *Penaeus serratus*, Bate, assuming the two forms to belong to distinct genera, sought by this means to emphasize its near relationship to the Atlantic MS species *Penaeopsis serratus* A. Milne

Edwards. *Penaeus serratus* from the Pacific is described by Bate on an earlier page than the mention of the Atlantic form, and since both species are now known to refer to the same genus, the name *serratus* has priority for the Pacific species. Bate, De Man, 1911, and Balss, 1925, believe that the Atlantic and Pacific forms, though closely related, are distinct. De Man therefore erects a new name, *Penaeopsis challengerii*, for one of the pair, but unfortunately applies it to the Pacific species; his name must therefore be placed in the synonymy of *P. serratus* (Bate). There seems no doubt that Smith's *Parapenaeus megalops* is identical with Milne Edwards' *Penaeopsis serratus*; the former name therefore replaces the latter, preoccupied one for the Atlantic species. If, however, *Penaeus rectacutus* (Bate) should be found identical with *P. serratus* (Bate), the former takes precedence over the latter by page priority, and the latter name again becomes available for the Atlantic species.

No clear diagnostic distinctions between *Penaeopsis rectacutus* (*Parapenaeus rectacutus* of most authors) and *P. serratus* have ever been established. Bate himself (1888) seems to have felt some uncertainty as to the distinctness of the two forms, and indeed, transferred some cotypes of *P. serratus* as first described, to *P. rectacutus*. If I interpret his ambiguous sentence correctly, Bate also suggests that one form may be only a variety of the other. Since the time of Bate both species have been reported, but the results of examination of both by the same worker have only been made public by De Man and by Balss, who placed the two in different genera, for no very evident reasons. The single specimen referred by the former author to *P. serratus* was a very early juvenile for contrast with which no juvenile specimens referred to *P. rectacutus* were available; while the latter author has not discussed the distinctions between specimens which he refers to the two species, and indeed, has figured for his *P. serratus* a thelycum resembling Bate's figure of *P. rectacutus* much more strongly than Bate's figure of *P. serratus*. Between accounts of one or the other species by Alcock, 1901 and 1906; De Man; Kemp and Sewell, 1912; and Balss, there are some differences which may or may not signify that two Indopacific species of the genus actually exist. A comparison of the literature with the extensive material of *P. megalops* available to me indicates the distinctness of the Atlantic from the Indopacific species, and may throw some light upon the differences between various accounts of Indopacific specimens.

In descriptions and figures of Indopacific material, the maximum number of rostral teeth is less than thirteen, of which none are behind the orbital margin. In only a few specimens of *P. megalops* were there less than fourteen rostral teeth, the mode being above fourteen, and the maximum eighteen; while one rostral tooth was always behind the orbital margin. The rostrum of *P. rectacutus* has been described as straight, that of *P. serratus* as arched. The rostrum of *P. megalops* was variably straight, to considerably arched especially in the smaller specimens, and was either horizontal or ascending.

The anterior cervical sulcus of *P. rectacutus* and *P. serratus* has for both been

described or figured as descending either obliquely or in a sigmoid curve. The sulcus in *P. megalops* descends in a sigmoid curve, the upper limb of which is, however, more oblique than in Bate's figure of *P. serratus*.

The telson of both Indopacific species is described as bearing two pairs of mobile spines save by Alcock, who found three pairs in specimens attributed to *P. rectacutus*. I have found a third pair of mobile spines in one specimen of *P. megalops*.

The second pair of chelipeds is described as unarmed in Indopacific material, save by Alcock who found a basal spine in females of his *P. rectacutus*; by Kemp and Sewell, who imply that it may be variably present or absent in *P. rectacutus*; and by Balss, who found it present in the two specimens referred by him to the same species. I have observed that the armature of the second leg is subject to occasional variation in species of the genus, one specimen of *Penaeopsis* (*Metapenaeopsis*) *mineri* lacking the basal spine present in other examples of that species. A second leg armature does not, however, occur in any of the available specimens of *P. megalops*, and it seems surprising that Alcock should describe, both for this character and that of telson armature, conditions rare in material of the subgenus available to others.

The distoventral angles of the petasma of Indopacific material have been described both as rounded and as produced. In *P. megalops* (figure 1) the angle appears either rounded or bluntly produced, dependent on the plane in which the margins are observed.

The thelyca figured by Alcock for his *P. rectacutus* and by Balss for his ? *P. challenger* seem without significant differences; both figures are probably within the limits of tolerance of Bate's figure of *P. rectacutus*. The thelycum of *P. megalops* seems different from the above by the fact that the posterior margin of the median plate overlaps the anterior median margins of the lateral hoods, instead of being overlapped by them, and is deeply emarginate rather than straight. The differences between Bate's figure of the thelycum of *P. serratus* and that of his *P. rectacutus* are superficially quite striking, but are perhaps not of great importance. In the immature thelycum of *P. megalops* the lateral hoods are reduced in size, which not only permits the transverse depression to gape widely, but exposes the lateral parts of the median plate to view. With some allowances for inaccuracy, Bate's figure of *P. serratus* is remarkably like what might be inferred as to the immature thelycum of *P. rectacutus*.

It therefore appears that without further studies of Indopacific materials, distinctions between *P. rectacutus* and *P. serratus* cannot be satisfactorily drawn. The fact that the two females referred by Balss to *P. rectacutus* possessed, like those referred to the same name by Alcock, a spine on the basis of the second legs, while like the material examined by De Man, they lacked the third pair of telson mobile spines observed by Alcock, seems to support the possibility that differences in these structures, the most obvious reported

between various Indopacific specimens, may be attributable to intraspecific, not interspecific, variation.

The presence of an anteriorly directed median spine on sternites XIII and XIV of "*P. serratus antillensis*" Milne Edwards and Bouvier and of "*P. challenger*" De Man, is a larval character present in the postmysis stages of many Penaeinae. The stage seems to be unusually prolonged in *Penaeopsis*, but is as much so in the postlarva of *Penaeus* species (*P. japonicus* Bate?) described by Stebbing, 1914, as "*Penaeus pulchricaudatus*," and in the possibly adult *Penaeopsis evermanni* (Rathbun), 1906, and De Man, 1911 (the latter reference being perhaps to the larva of another species rather than to the form described by Rathbun). The fact that exopods were absent from the walking legs of De Man's very young individual of "*P. challenger*" is evidently another of the attributes, as in other Penaeinae, of this SICYONINE stage in ontogeny. In juvenile males of *P. megalops*, in addition to the spines of sternites XIII and XIV which disappear in the adult, there is a persistent blunt protuberance on XII which represents a spine similar to the more posterior ones. In juvenile females, this protuberance of XII in males is represented by a sharp tooth, which becomes converted to a blunt knob in the adult. The spine of XIII in juvenile females is represented in adults by the anterior part of the median plate of the thelycum.

In addition to sexual differences in antennular flagella which have been noted by several workers for species of the subgenus, it may be mentioned that the third segment of the antennular peduncle of *P. megalops* is in the adult male much stouter than in the female. The thelycum very closely resembles that of *Parapenaeus longirostris* (Lucas), Burkenroad, 1934, especially in internal structure.

It seems probable that a Pacific American congener of *P. megalops*, at present not known, will be found. The species is not strictly speaking a littoral one but has been included in the present paper for convenience in treating the genus.

SUBGENUS **METAPENAEOPSIS** Bouvier

Penaeopsis goodei (Smith)

Figures 2 and 3, page 23.

? *Penaeus pubescens* STIMPSON, 1871.

Parapenaeus goodei SMITH, 1886.

Parapenaeopsis rathbuni BOUVIER, 1905b.

Archipenaeopsis vestitus BOUVIER, 1905b.

Metapeneus goodei ALCOCK, 1906.

Penaeopsis goodei MILNE EDWARDS and BOUVIER, 1909; DE MAN, 1911;

SCHMITT, 1924a; BOONE, 1927, part.

Penaeopsis vestitus SCHMITT, 1924a.

1 male, carapace 7 mm; 2 females, carapace 8 and 9.3 mm. *B.O.C.* 24. Dry Tortugas, Florida, February 10, 1931.

1 female, carapace 11 mm. *B.O.C.* 22. Saddle Rock, Bahamas, March 23, 1925.

2 females, carapace 7.5 and 10.5 mm. *B.O.C.* 23. Royal Island Harbour, Eleuthera Island, Bahamas, April 14, 1925.

1 male, carapace 8.8 mm. *B.O.C.* 21. Swan Island, Caribbean, April 12, 1925.

1 male, carapace 5.3 mm, 5 females, carapace 10 to 6.5 mm. *B.O.C.* 20. Glover Reef, Gulf of Honduras, April 16, 1925.

The Bingham material has been directly compared with Smith's type, a male of carapace length 11 mm from the Bermudas, in the collection of the Zoology Department of the Peabody Museum of Natural History.

Penaeopsis goodei (Smith) of Milne Edwards and Bouvier includes a male, of which the telson was figured, originally mentioned as *Parapenaeopsis rathbuni* Bouvier; and a female, of which several figures including one of the thelycum were given, originally mentioned as *Archipenaeopsis vestitus* Bouvier. The characters which lead Schmitt, 1924a, to suggest the separation of these specimens from *Penaeopsis goodei* seem of little importance. The nature as described by Bouvier of the setae of the branchial region—simple rather than compound—is, as will be shown in a succeeding paragraph, probably not a valid distinction. The figure of the thelycum, although inaccurate, is that of an immature female of *P. goodei*. The statement that the right lamella of the petasma of the male is spoon-shaped makes it probable that this specimen is also *P. goodei*. There is nothing to suggest, as Schmitt thinks possible, that the male belongs to still another species than the female.

In *P. goodei* as well, as in the other American species of *Leptopenaeus* which have been examined, the third maxillipedes and the first and second legs have a basal armature, and the first legs an ischial spine.

A third Atlantic species of *Metapenaeopsis*, known since Bouvier, 1905a, as *P. pubescens*, occurs on the west coast of Africa. This species seems closely related to, but distinct from, *P. goodei* by the structure of its thelycum according to a figure by Balss, 1916, as well as by certain other characters, such as the elongated second pair of mobile lateral spines of the telson noted by Milne Edwards and Bouvier, 1909. The attribution to Stimpson, 1871, of the name *P. pubescens* as applied to this Eastern Atlantic species is improper.

Penaeus pubescens was described by Stimpson from the West Indies. His account has been generally assumed to refer to a species of the genus *Penaeopsis*, but although in part applicable, the description in some points fails to coincide with characters universally displayed by that genus. In such points as Stimpson's notations agree with those of the African *Penaeopsis*, they agree to the very same extent with the West Indian *P. goodei*. Since there is no available evidence that the African form ranges to the Antillean type locality of *Penaeus*

pubescens Stimpson it seems necessary either to apply the name *pubescens* Stimpson to *Penaeopsis goodei* or to apply it neither to this nor to the African form. It is possible that the name *Penaeus pubescens* does not refer to any species of *Penaeopsis* at all. Stimpson's statements (which usually may be relied upon) that the leg bases of this species are unarmed and that the telson bears only one pair of lateral spines, fail to agree with what is very conspicuously the state of all known species of *Penaeopsis*. The only other genus to which the remainder of the description might apply seems to be *Parapenaeopsis*, in various species of which a carinated second pleonic somite, lack of postrostral carina and produced anteroinferior angle of the carapace, as well as unarmed leg bases and reduced telson armature, are known. The discovery of the new species *Parapenaeopsis balli* on the Pacific American coast, coupled with the occurrence of the related *Parapenaeopsis atlantica* Balss in the Eastern Atlantic, renders it possible that a since-undiscovered species of *Parapeneopsis* from which Stimpson's description of *Penaeus pubescens* was drawn exists in the Western Atlantic. Therefore, since Stimpson's name may be provisionally accepted as referring to another genus, and since the appellation *P. velutinus* Dana of Miers, 1881, is obviously not applicable, the West African species of *Penaeopsis* may be known as *P. pubescens* (Bouvier).

***Penaeopsis smithi* Schmitt**

Figures 4, 5, and 6, page 21; figure 7, page 24.

Penaeopsis smithi SCHMITT, 1924a, 1924b.

Penaeopsis goodei BOONE, 1927, part.

2 females, carapace 10 mm. *B.O.C.* 25. Saddle Rock, Bahamas, surface, March 23, 1925.

1 female, carapace 9.5 mm. *B.O.C.* 27. Green Cay, Bahamas, seine, March 13, 1927.

1 female, carapace 10 mm. *B.O.C.* 26. Green Cay, Bahamas, surface, night, March 17, 1925.

4 females, carapace 7.5 to 11 mm. *B.O.C.* 28. Green Cay, Bahamas, surface, February 27, 1927.

1 male, carapace 7 mm; 11 females, carapace 9 to 10.5 mm. *B.O.C.* 29. Swan Island, Caribbean Sea, April 12, 1925.

In addition to the above, three immature and one subadult male ranging from 4 to 6 mm in carapace length; and one immature female 5 mm in carapace length, from the Bahamas, Cuba, and Puerto Rico were made available by the American Museum of Natural History. The present records extend the known range of *P. smithi* considerably to the northward.

The pubescence of the branchial region of the carapace of *Penaeopsis smithi* is plumose at least in major part, and is not, as stated by Schmitt, simple; there are no qualitative differences in the nature of the tomentum between *P.*

smithi and *P. goodei*, although there appear to be quantitative ones. The pinnulae of the setae, which are arranged upon the shaft like the barbs of a feather, are, especially in *P. smithi*, readily rubbed off, when little trace of the points of attachment remains. The setae of both species show some differentiation into two types, the one short, stout and curved with stout and rigid pinnulae; the other long and slender with long, flexible, less easily detached pinnulae. The setae of the second type are most abundant on the branchial region just above the membranous branchiostegite, and in advance of the hepatic spine. Setae of the first type are perhaps shorter and sparser, and with more delicate pinnulae in *P. smithi* than in *P. goodei*. It is possible that intermixed with the compound setae in the former species a few truly simple ones may occur, but owing to the ease with which the pinnulae are lost, this is difficult to determine.

The length and proportions of the telson tip, and its lateral armature are subject to some variation, as is also the degree of accentuation of the median dorsal ridge of the third pleonic somite. These characters are of considerable value in distinguishing *P. smithi* from *P. goodei*, but are perhaps not completely diagnostic. Schmitt, 1924b, in describing *P. smithi* as differentiated from *P. goodei* by its slender telson tip, has probably reversed the statement that he wished to make. Measurement of the length of the external scale of the antennular peduncle by comparison with the cornea of the eyes is not satisfactory, since the apparent length of the latter varies with its rotation and by shrinkage. A measurement of the scale against the length of the basal segment of the peduncle exclusive of the spine at its anteroexternal corner indicates that the scale is, although variable, usually somewhat longer in *P. goodei* than in *P. smithi*, as correctly stated by Schmitt. We may perhaps doubt the accuracy of the comparison of *P. goodei* with *P. pubescens* in this character by Milne Edwards and Bouvier.

Schmitt's figures of the thelycum of *P. smithi* and *P. goodei* are not accurate, but are sufficient for recognition of the adults; his text is erroneous, the thelyca being compared in nonhomologous parts.

The simpler thelycum of *P. goodei* may be considered first. Its structure is as follows: Near the posterior margin of sternite XIV is a raised transverse belt the anterior margin of which is cut into three projecting ridges, a median flanked by a pair of laterals. Anterior to this belt is a tilted subrectangular transverse area the posterior part of which is depressed and is overhung by the posterior elevated belt, while its straight anterior margin is elevated. From the middle of the anterior margin of the subrectangular area a longitudinal elevated bridge, posteriorly broad and anteriorly narrow, runs forward to join the anteromedian part of the median plate of sternite XIII. From the lateral part of the subrectangular area on either side there extends forward a raised plate, the LATERAL HOOD of sternite XIV. The transverse groove between sternites XIV and XIII, the hollow of which serves as sperm-receptacle, runs along the anterior and median margins of the lateral hood on either side, and is continued mediad

along the anterior margin of the subrectangular area to the longitudinal bridge, the lateral margins of which it follows forward to the juncture of the bridge with the median plate. The transverse groove thus has the shape of a cursive *w* the two halves of which are separated by the median bridge. The median plate of sternite XIII gives rise from its posterolateral margins to elevated laterally directed ridges, the LATERAL PARTS, between which and the anterior margins of the lateral hoods of sternite XIV the lateral portions of the transverse groove are bounded. The median plate of XIII is continued posteriorly on either side of the midline by an oval, elevated boss which occupies the space between the lateral hoods and the median bridge of XIV. The anteromedian extremity of the transverse groove on either side is expanded and forms a pit between the posterior part of the median plate and the median bridge. From this pit in impregnated females a plug of male secretion protrudes; it is probable that the spermatophores are inserted into the receptacles at these two points. The receptacles are formed simply from the rather shallow fissure of the transverse groove, which is most deeply invaginated beneath the lateral hoods, but does not give rise to a large membranous sac as in *Penaeopsis megalops*.

The thelycum of *Penaeopsis smithi*, in spite of superficial dissimilarity, is built upon essentially the same plan as the above. The subrectangular area of sternite XIV is very much shorter along its longitudinal axis than in *P. goodei*, and is much less clearly set off from the posterior, three-ridged transverse belt. The lateral hoods extend much farther anterolaterad and posteromedial. The longitudinal bridge is extremely narrow and very long; its anterior part being hidden by the overlapping of the posterior parts of the median plate of XIII. The anterior part of the median plate is reduced to a very narrow curved strip. The posterior part on either side, equivalent to the short oval bosses of *P. goodei*, is much elongated commensurate with the reduction in length of the antero-median region of the median plate of XIII and of the subrectangular area of sternite XIV. The median limbs of the transverse groove are thus greatly elongated; further, instead of terminating at the point where it reaches the median plate, as in *P. goodei*, either median limb of the groove turns laterad, then to posterior, then, turning sharply anteriorad, descends beneath the surface of the posterior part of the median plate as a deep closely wound spiral pit. From this pit the groove agains runs posterolaterad across the posterior part, to terminate in a broad depression. The significance of these highly complex convolutions of the anteromedian limbs of the transverse groove is unknown, since only that portion equivalent to the groove of *P. goodei* seems to be utilized in sperm storage. In the smallest female of *P. smithi* which I have examined the thelycum is almost indistinguishable from that of adult *P. goodei*, except that the continuations of the anteromedian ends of the transverse groove are present in simple form, almost effecting the isolation of the posterior from the anterior parts of the median plate.

Schmitt's description of the thelyca of *P. smithi* and *P. goodei* errs in his homologization of the elevated anterior part of the subrectangular area of *P. goodei* with the lateral hoods of *P. smithi*, which he regards as the lateral portions of a similar transverse plate which has been "virtually obliterated" in the mid-line. The lateral hoods of *P. goodei* are completely omitted from the comparison, and would, in the figure offered by Schmitt, be hidden by the fourth leg bases. The "longitudinal curved elements" described by Schmitt for *P. smithi* represent those portions of the posterior parts of the median plate which lie mediad

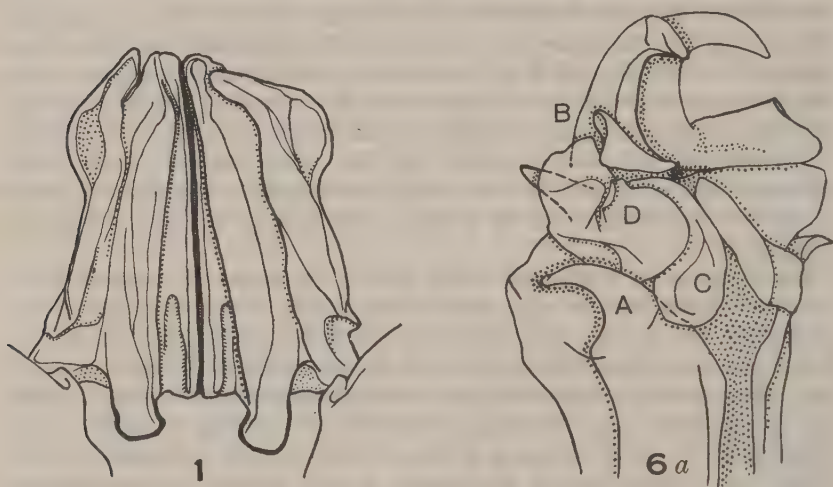


Figure 1. *Penaeopsis megalops* (Smith).

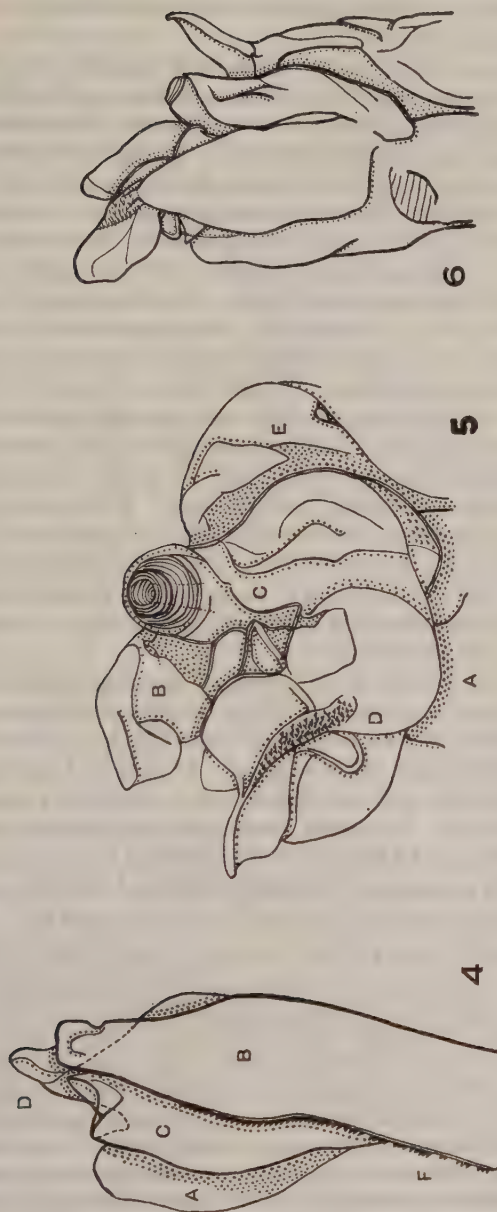
Petasma, ventral view $\times 9$.

Figure 6a. *Parapenaeus longirostris* (Lucas).

Petasma, distal portion, ventrolateral view (Louisiana adult) $\times 28.5$. Lettering as in figure 5.

the continuation of the transverse groove, and are not by themselves equivalent to the "rounded platelets" of *P. goodei*. Schmitt's description and figure of two "platelets" on each side in *P. goodei* is probably based on an impregnated female, in which he has mistaken the plug of male secretion protruding from the terminus of the transverse groove for a second "platelet" anteromedian to the posterior part of the median plate, the first "platelet."

The two species under discussion are very distinct in petasmal structure. As a preliminary to the statement of these differences, it is necessary that the structure and derivation of the asymmetrical petasma be elucidated. Kishinouye, 1929, is the first to describe the complicated male copulatory organ of the "asymmetrica" completely, but his account is of little value in interpreting

Figure 4. *Penaeopsis smithi* Schmitt.

Petasma, juvenile, right ramus, dorsal view $\times 48$. Lettering as in figure 5.

Figure 5. *Penaeopsis smithi* Schmitt.

Petasma, adult, distal portion, right external piece removed, ventrodistal view $\times 45$.

A. Right distoventral projection (external piece).

B. Right distomedian lobe (proximal part).

C. Right distoventral flap (convoluted distal part).

D. Right distolateral lobe (second distal part).

E. Distal portion of left endopod.

F. Clincinnuli on median edge of distomedian lobe.

Figure 6. *Penaeopsis smithi* Schmitt.

Same as figure 5, ventral view $\times 30$.

the homologies of the appendage. For his nomenclature, one capable of more general application will here be substituted.¹

The copulatory appendages of the first male pleopods of penaeids may be termed endopods, an interpretation supported by their ontogeny, and by the nature of the homologous rudimentary structures of the female. The terms ventral and dorsal will be applied as though the petasma lay parallel to the long axis of the shrimp. From the ventral face of each petasmal endopod in the subgenus *Metapenaeopsis*, nearer to its distal than its proximal end, springs a lamella (the "external piece" of Kishinouye) which may completely cover the more distal portion ("internal piece"). The proximal portions of the two petasmal endopods of *Metapenaeopsis* are not symmetrical, but are otherwise enough like those of the normal petasma to need no description. The appearance of the proximal portions, and that of the right "external piece" may be observed in the appended ventral views of the whole petasma. The left "external piece" is in the Indopacific species longer than the right one, but in the American species it is reduced to a vestige. The "internal piece" of the left endopod of the petasma may be simple or may be divided into more than one lobe; in the American species it is a simple flexible flap. The right "internal piece" is divided into three main lobes which may be subdivided. One of these (the "proximal part") is on the dorsal side of the endopod. A second (the "convoluted distal part") occupies the median margin of the distal portion of the endopod. A third (the "second distal part") is placed ventrolaterally and bears spinules upon at least one of the lobes into which it may be subdivided.

In the simple open petasma of *Penaeus* or of *Penaeopsis megalops* the distal margin of each endopod is more or less divided into three main lobes or regions. The most median of these, which may be termed the DISTOMEDIAN LOBE surmounts the hook-bearing median margin of the endopod. The second lobe, the DISTOLATERAL, is placed lateral to the first, and distolateral to the end of a deep longitudinal pleat of the endopod. In certain forms, such as *Penaeus*, the dorsal surface of this second lobe may be spinulose. Ventrolateral to the second lobe is placed the third, which surmounts the usually chitinized and rib-like ventrolateral margin. This third lobe may be termed the DISTOVENTRAL.

¹ A somewhat similar descriptive system has been proposed by Balss, 1927 (Wiss. Ergeb. Deutschen Tiefsee-Exped., XXIII, 6), for the open petasma of the Aristaeine *Amalopenaeus*. Of the terms given in a further paragraph, DISTOLATERAL LOBE is equivalent to "Lobus medianus" of Balss. The DISTOVENTRAL FLAP is equivalent to "Lobus externus" of Balss. The DISTOVENTRAL PROJECTION, which with the flap makes up the DISTOVENTRAL LOBE, is not named in Balss' system, although in *Amalopenaeus*, as in *Metapenaeopsis*, the two structures are separated. The DISTOMEDIAN LOBE is not distinguished by a name in Balss' system. Since the terms proposed by Balss are not sufficiently complete for general application, the nomenclature proposed in a succeeding paragraph is not withdrawn, although to the extent to which the two systems are equivalent it presents no advantages.

In the more complex petasma of *Trachypeneus*, *Eusicyonia*, *Metapenaeopsis* or *Parapenaeus*, the endopod is longitudinally folded over in such a manner that the margin which in the open petasma was lateral, is here ventromedian, and the endopod in cross-section would have the shape of a U with the closed end placed laterally. The median edge of the dorsal limb of this U bears the hooks or cincinnuli by which the endopod is hooked to its fellow of the opposite side, while the ventral limb of the U may not extend so far mediad as does the

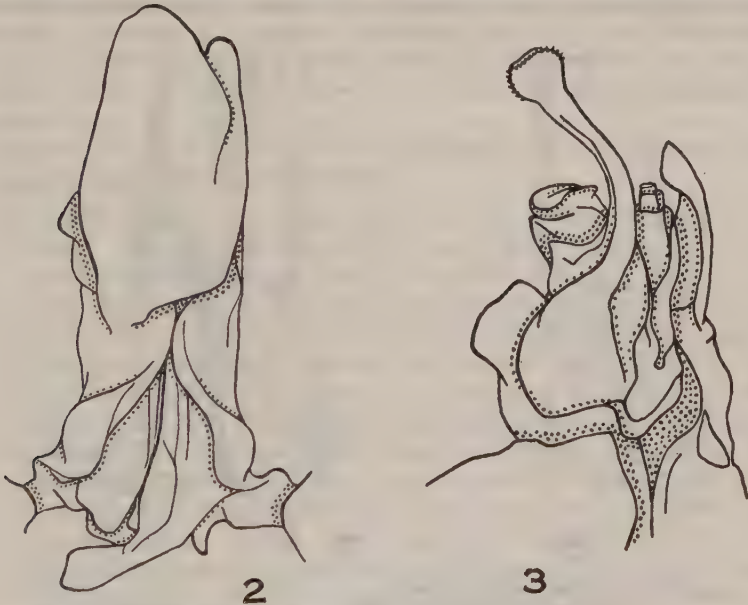


Figure 2. *Penaeopsis goodii* (Smith).
Petasma, ventral view $\times 12.5$.

Figure 3. *Penaeopsis goodii* (Smith).
Petasma, distal portion, right external piece removed, ventral view $\times 18.6$.

dorsal, and does not become attached to the ventral limb of the opposite endopod to form a perfect tube.

A careful examination of the juvenile state of the asymmetrical petasma of *Metapenaeopsis*, and comparison with the adult state, reveals that this petasma is of the same basic pattern as that of other peneids. Kishinouye's "proximal part" surmounting the cincinnulated median margin of the endopod, is a fleshy, subdivided distomedian lobe. Kishinouye's "second distal part" is a much thickened and divided distolateral lobe; as in many forms with open petasma, a portion of this lobe in *Metapenaeopsis* is spinose. Finally, Kishinouye's "convoluted distal part" is, with the "external piece," a portion of the disto-ventral lobe of the petasma. In the adult male, the "convoluted part" forms

a tight roll of thin chitinized tissue, which may become unwound, when, as in the figure of *P. mineri*, it projects as a spirally twisted flap. This rolled-up flap is continuous ventrolaterally with the distolateral lobe; while dorsomedially it is free from although touching against the cincinnulate median margin and the distomedian lobe. The "convoluted distal part" thus seems to represent the produced free margin of the distoventral lobe, which has been rolled up like a flat spring. In the juvenile petasma figured, the distoventral lobe has as yet been no more produced than to form a single whorl. The "external piece" of

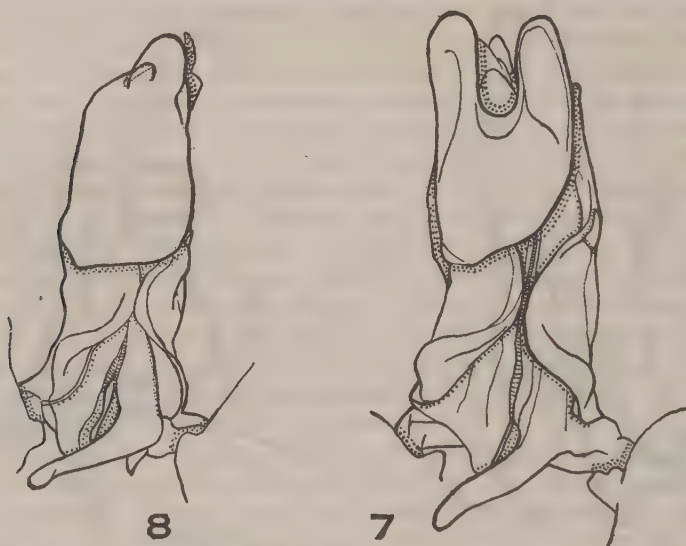


Figure 7. *Penaeopsis smithi* Schmitt.
Petasma, ventral view $\times 20.4$.

Figure 8. *Penaeopsis mineri*, n. sp.
Petasma, ventral view $\times 20.4$.

the asymmetrical petasma appears to represent the main portion of the distoventral lobe of the open petasma, in which latter it often forms a stout projection. As the coiled flap is to be regarded as produced from the margin of this same lobe, the "external piece" may be termed the DISTOVENTRAL PROJECTION, and the "convoluted distal part" the DISTOVENTRAL FLAP.

The symmetrical petasma of *Parapenaeus longirostris* (Lucas) (figure 6a) carries a distal armature of lobes and spines which seem to be homologous in detail with the very complex distal armature of the asymmetrical petasma of *Metapenaeopsis*; the petasma of *Parapenaeus* shows a much greater resemblance to the highly specialized one of *Metapenaeopsis* than does the petasma of any other peneid. Thus, corresponding to the distomedian lobe of the right endopod of *Penaeopsis smithi*, which is subdivided into a dorsal and a ventral

element, there is in *Parapenaeus* a large dorsomedian spine-like projection which carries a fleshy flap at the inner side of its base. Corresponding to the distolateral lobe in the *Metapenaeopsis*, which is composed of a projecting, divided, spinulose inner part proximolateral to which is a projecting lobulate bracket, there is in the *Parapenaeus* a broad lateral spine, with a fleshy flap at its base which is continuous with the first flap. Corresponding to the distoventral coiled flap in the *Metapenaeopsis* there is an unproduced fleshy flap in the *Parapenaeus*, continuous with the flap lateral to it, but with a free median margin. Corresponding to the distoventral projection in the *Metapenaeopsis* there is a stout spine in an equivalent position in the *Parapenaeus*, from the inner side of which the flap homologous with the coiled flap of *Metapenaeopsis* takes rise.

Between the adult petasma of *P. smithi* Schmitt and that of *P. goodei* (Smith) the following are the chief differences:

- P. smithi*—Right distoventral projection deeply cleft into two subequal lobes. Left endopod not extending nearly as far distad as does the right distomedian lobe. Inner part of the distolateral lobe a blunt vertical cone (not extending much above the level of the distomedian lobe) joined to the dorsolateral edge of which is a projection which does not rise above the level of the cone. Spinules are placed on the distal surface of the projection in the region where it joins the cone. At the base of the left endopod, laterad the projecting median spur, is a low rounded prominence.
- P. goodei*—Right distoventral projection less deeply cleft, the left lobe usually smaller than the right. Left endopod extending nearly as far distad as does the right distomedian lobe. Inner part of the distolateral lobe a greatly produced slender clavate projection rising far above the level of the distomedian lobe, and bearing spinules upon its distal surface. Laterad the median spur at the base of the left endopod is a long slender tooth, visible even in dorsal view.

***Penaeopsis (Metapenaeopsis) mineri*,¹ new species**

Figures 8, page 24; 9 and 10, page 27.

1 female, holotype, *B.O.C.* 39. Conception Bay, Lower California, May 26, 1926.

In addition to this specimen, there are contained in the collection of the American Museum of Natural History a male and a female from the Gulf of California, which may be regarded as paratypes; and a male from Saboga Island, Pearl Islands, Gulf of Panama.

Dimensions—Holotype, total length about 48 mm, carapace 11.3 mm, rostrum 7 mm, telson broken. Paratype female, total 32 mm, carapace

¹ Named for Dr. Roy Waldo Miner.

6.5 mm, rostrum 3.9 mm, telson 4.5 mm. Paratype male, total 30 mm, carapace 6 mm, rostrum 3.2 mm, telson 3.8 mm.

Description—Rostrum straight, slightly above or below the horizontal, ranging in extent from the basal fourth of the second segment of the antennular peduncle to the last third of this segment. Rostrum armed above with 9 or 10, usually 10 teeth in addition to the epigastric. Teeth large, crowded; first tooth well in advance of the orbital margin. A line through the tips of the teeth describes a curve whose highest point is at about the third or fourth tooth. Anteriormost tooth from one to one and one-half times as far from the tip as from the penultimate tooth. Epigastric tooth placed nearly at the anterior one-fourth of the carapace.

Orbital angle dentiform. Pterygostomian spine slender, acute; behind it the ventral margin slopes first downward, then backward. Dorsal cervical sulcus short; ventral continuation of the cervical sulcus somewhat sigmoid, turning obliquely downward anterior to the hepatic spine in the direction of the ventral margin, which it does not reach. Cardiac-branchial sulcus and carina absent. Postrostral carina disappears just in front of the epigastric tooth, the buttress of which extends posteriorly for only a very little way.

Third pleonic somite dorsally compressed to a faint median longitudinal peak; fourth, fifth and sixth somites carinated. The carina of the sixth somite only ends posteriorly in a tooth. There is a shallow transverse sulcus on either side of the median line of the second somite. The lateral fixed spines of the telson are short, not reaching to the middle of the long slender tip. The posterior of the three pairs of mobile spines reaches to or falls short of the tips of the fixed spines; the penultimate pair of mobile spines reaches a little beyond or falls short of the bases of the ultimate pair.

The carapace is thickly set with plumose setae, sparsest in the branchial region, strongest on the branchiostegal region and in the sulci. The pleon bears patches of tomentum, most extensive dorsally.

The sternal spines between the bases of the second legs are long and slender in both sexes.

Conspicuous sexual modification of the antennular flagella, which are somewhat shorter than the last two segments of their peduncle, is lacking. The external scale of the basal segment of the antennular peduncle is considerably less than one-half the length of the external margin of the segment. The minute spine of the ventromedian margin of this segment is placed less than one-third the length of the segment from its anterior end. The third pereopods variably extend from four-fifths the length of the antennal scales as much as to their tips. The first legs are bispinose; the third maxillipedes bear a basal spine. The second legs have a basal armature in the three specimens from the Gulf of California but lack the spine in the Panamanian male. The exopods of the walking legs are long and slender, reaching to or beyond the distal end of the ischium.

The thelycum, although superficially strikingly dissimilar, actually represents a modification of the same basic pattern characteristic of *P. goodei* and *P. smithi*. The transverse belt of the posterior portion of sternite XIV bears distinct lateral projecting ridges, but the median ridge of this belt is only differentiated from the subrectangular area lying anterior to it by the presence of a line of setae, such as in *P. goodei* crown a veritable ridge. The subrectangular area is very conspicuous. Its anterior margin is much elevated, and far over-

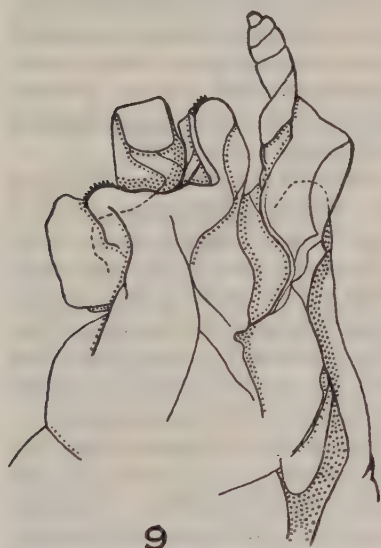


Figure 9. *Penaeopsis mineri*, n. sp.

Petasma, distal portion, right external piece removed, ventral view $\times 33.3$.

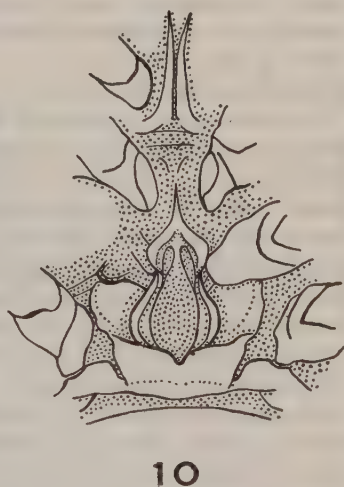


Figure 10. *Penaeopsis mineri*, n. sp.

Thelycum $\times 16$.

hangs the posterior end of the median longitudinal bridge, as well as the posterior portions of the oval bosses of somite XIII. Medially the anterior margin of the subrectangular area is deeply notched. Anterolaterally the subrectangular area is continued into the large lateral hoods, from which it is incompletely separated by a ridge. The longitudinal bridge is posteriorly very broad; anteriorly it narrows considerably before joining the anterior part of the median plate of XIII. This part of the median plate forms a narrow U-shaped elevation, from the closed anterior end of which springs a long, slender, anteriorly directed spine. From the posterolateral margins of the median plate extend the laterally directed ridges (the LATERAL PARTS) which overlap the anterior margins of the lateral hoods and with them enclose the lateral portions of the transverse groove. The ends of the U-shaped anterior part of the median plate are sepa-

rated from the structures representing the posterior parts by a deep narrow transverse cleft. Each posterior part has the form of a very elongate, high lamella, the posterior end of which is hidden under the subrectangular area, while between the two lamellae the much less elevated longitudinal bridge is enclosed as a deep oval depression overgrown with setae. The transverse groove turns to posterior on either side between the median margins of the lateral hoods and the bases of the lamelliform posterior parts, and is continued to the posterior ends of the lamellae, beneath the overhanging subrectangular area. The groove appears to turn anterior here, and to continue up the median sides of the posterior parts, between them and the longitudinal bridge, to the anterior part of the median plate. It is anteromedially so shallow, however, that it is probably no more than a vestige bereft of the sperm-storing function which this portion of the groove possesses in *P. goodei* and *P. smithi*.

The distoventral projection of the right endopod of the petasma is shallowly cleft into a small right and a large left lobe. The left distoventral projection is rudimentary. The tip of the left endopod does not extend nearly as far distad as does the right distomedian lobe. The median part of the right distolateral lobe differs from that of both *P. goodei* and *P. smithi* in that it bears spinules in two separated patches, upon the tip of a lateral lobe as well as upon the distal end of a medial projection extending considerably further distad than does the lateral projection. At the base of the left endopod, laterad the median spur, is a proximomedially directed tooth sometimes visible in ventral view.

The reference of Smith, 1886, to *P. goodei* from the Bay of Panama is probably to be regarded as founded on specimens of *P. mineri*, as is probably also the record by Boone, 1930, of *P. kishinouyei* Rathbun from Costa Rica. *P. kishinouyei* of Boone, 1931, from Panama, is the male of *P. mineri* referred to above. *Penaeopsis* species, Schmitt 1924c, from Lower California, is perhaps the present form.

Penaeopsis mineri is, although much more closely related to them than to any described Indopacific species, so distinct from the Atlantic American species as to make it impossible to decide with which of them its affinities lie. It is perhaps somewhat more nearly related to *P. goodei*.

If the description of *Penaeopsis kishinouyei* Rathbun, 1902, is accurate, as the fact that Schmitt, 1927, does not offer to modify the definition originally set forth seems to indicate, then the present species is quite distinct from the Galapagos form. The right distoventral projection of the petasma of *P. kishinouyei* is figured as deeply cleft and with the right lobe much larger than in *P. mineri*. Rathbun's statement that the left half of the petasma is longer than the right, if actually based on the left endopod and not on a median lobe of the right one, is a clear distinction. The anterior part of the median plate of the thelycum, as figured and described, lacks a median spine; the striking lamelliform posterior parts characteristic of *P. mineri* are not indicated, and indeed the "lateral plates" are described as broad and fused. The rostrum as

described bears a smaller number of teeth, and the epigastric tooth seems to be placed farther posterior than its position in *P. mineri*.

METAPENAEUS Wood Mason and Alcock, restricted

Metapenaeus, WOOD MASON and ALCOCK, 1891, part; ALCOCK, 1905 and 1906, part; NOBILI, 1903 and 1906, part.

Penaeopsis, MILNE EDWARDS and BOUVIER, 1909, part; DE MAN, 1911, part; SCHMITT, 1926a, part.

Not *Metapenaeus*, RATHBUN, 1919; STEINITZ, 1932.

Metapenaeus affinis (H. Milne Edwards)

Penaeopsis affinis, DE MAN, 1924.

1 male, semimature, total length 81 mm. *B.O.C.* 42. Georgetown, Penang, February, 1932.

Of the twenty named species¹ which may be attributed to *Metapenaeus* as here restricted, eight seem to be forms closely related to *M. affinis*. This group of nine named species is somewhat difficult of precise evaluation. Of it, *Penaeus villosus* Guérin-Mèneville, 1830, appears from the description to be a member of the *M. affinis* group, but the subsequently published figure appears to represent a species of *Penaeopsis*. The name, in the absence of a type from which its characters might be more definitely determined, may be discarded.

The figured male of *Penaeus incisipes* Bate, 1888, is, as pointed out by De Man, apparently a specimen of *M. monoceros* (Fabricius). Although in his description Bate states that the species lacks basal spines on the third legs (a negative character not found among known species of *Metapenaeus*) these spines are shown as present in the figure of the male. In the figure of the female referred to the same species, Bate has shown no spines on either the third or the second legs; further, the thelycum is not of the type characteristic of *Metapenaeus*. It thus seems probable that to the male of *M. monoceros* or *M. affinis*, Bate has joined a female of another genus, perhaps *Parapenaeopsis*.

In *Metapenaeus deschampsii* Nobili, 1903, the largest male described, clearly immature since the petasml endopods were not yet joined, was of a size at which the meral notch of the fifth legs is in *M. monoceros* sometimes extremely inconspicuous. The figure of the thelycum, with due allowance for Nobili's diagrammatic mode of representation, seems indistinguishable from that of *M. monoceros*. It must, however, be admitted that even at the small size of

¹ It may be mentioned that *Metapenaeus palaestinensis* Steinitz, 1932, is a *Trachypeneus*, evidently a migrant through the Suez Canal, which by a misinterpretation of the posterior arthrobranch of XIII as a pleurobranch and other errors, and by a mistaken application of Alcock's definition of *Metapenaeus*, was placed in that genus without its having been observed by the author that *Metapenaeus* as defined by Alcock had sometime before been relegated to the synonymy of *Penaeopsis*.

60 mm. the coxae of the fourth legs of females of *M. monoceros* bear an easily perceptible projection stated by Nobili to be absent in his form.

M. elegans De Man, which is described (1911) as closely related to *M. affinis* but differing from it by shorter fifth legs and a different petasma, seems in these and other characters to fall within the range of somewhat immature *M. monoceros*. Thus, a poorly marked median dorsal carina on carapace and pleon may occur in immature specimens of *M. monoceros*, while the absence of the projection at the distal end of the ischium of the fifth legs of *M. elegans* is not diagnostic since this feature is not constantly present in young specimens of *M. monoceros*. To satisfactorily differentiate the two species on the basis of present information seems difficult.

M. cognatus Nobili (1906) is as described not differentiable from *M. monoceros*. The numerous small mobile spines present along the margins of the telson are not diagnostic of Nobili's form, for although the telson of *M. monoceros* and of many other species of the genus has been stated to lack a lateral armature, mobile spines appear to be present in all.

M. spinulicauda Stebbing, 1914, is quite possibly an immature specimen of *M. monoceros*. A lateral armature of the telson, as mentioned above, cannot be utilized to distinguish this from the latter species. The armature of the endopod of the second maxilla, given by Stebbing as a significant character, seems to be equivalent to that of the maxilla of *M. monoceros* except that in the latter there are three very small spines proximad the two large ones which were perhaps overlooked by Stebbing. The petasma of *M. spinulicauda*, which is that of a quite immature individual, is not distinguishable from this organ in *M. monoceros* of the same size. If Stebbing is actually dealing with *M. monoceros*, he has overlooked the spine at the distal end of the ischium of the first leg; it seems possible that this has occurred, since the presence of a basal spine on the third legs, characteristic of the genus, has also been overlooked.

M. mutatus Lanchester, 1901, is not by the description and figures differentiable from *M. affinis* as figured by Alcock, 1906, and De Man, 1924, with which species the author failed to compare it. The possible identity of *M. mutatus* with *M. affinis* has been suggested by Alcock.

M. demani Roux, 1917, may be mentioned in this place. The form, as described, seems to be very like *M. macleayi* Haswell as described by Schmitt, 1926a, although not mentioned by the latter author in his discussion of Haswell's species. The telson of *M. demani* is described as unarmed, while that of *M. macleayi* is stated to bear four pairs of marginal spinules, but to judge by the condition in the remainder of the genus, *M. demani* probably bears lateral armature of some sort. The arrangement of the rostral spines, regarded by Roux as diagnostic of his form, seems not very different from that found in *M. affinis*, and even more like that of *M. macleayi*. The median lobe of the petasma is thrown into folds along its lateral margin which seem somewhat

to resemble those of the male of *M. affinis* contained in the present collection. The precise affinities of *M. demani* are not at present clear, but it is probably not very closely related to *M. affinis*.

As to the two well-established species of the group, *M. affinis* and *M. monoceros*, no clear statement of diagnostic distinctions between them has been made. It would appear that although the dorsal median carination of the carapace and pleon of *M. affinis* may be weaker than that of *M. monoceros*, the range of variation in both species is sufficient to create considerable overlap; likewise the length of the appendages and the number of rostral teeth (the first usually greater, the last usually less in *M. affinis* than in *M. monoceros*) seem too variable to be of diagnostic value. Differences in the shape of the rostrum (somewhat sigmoid and cristate in *M. affinis*, straight in *M. monoceros*) perhaps provide a fairly constant criterion. The occurrence of a spine at the distal end of the ischium of the first legs, absent in my specimen of *M. affinis* but present though of variable size in all material of *M. monoceros*, may be of significance, but this structure is in related forms, as *M. lysianassa*, not constant in its occurrence.

The meral notch, tooth, and margin distad the tooth of the fifth leg appear to become distinctive only in very fully adult males, such as have been rarely reported. In the single male of *M. affinis* at my disposal, the tooth is short and triangular, as it is in the single nearly adult male of *M. monoceros* in the collection; the margin of the merus of the latter, behind the tooth, is entire just as in *M. affinis*. A projection is present near the distal end of the ischium of the male of *M. monoceros* which is not present in the other less nearly mature males nor in the specimen of *M. affinis*. The proximal part of the external margin of the exopod of the uropods is in the male of *M. affinis* conspicuously concave, while it is in all the specimens of *M. monoceros* not emarginate; however, both Alcock, 1906, and Kishinouye, 1900, figure the emargination as present in their specimens of the latter species. The protuberance reported to occur on the peduncle of the uropods of *M. affinis* is not visible in the present specimen. Some doubt of the diagnostic value of the various characters mentioned in the present paragraph is permissible; at any rate they seem of use only for the differentiation of large, mature individuals, and it is quite possible that the undistinctive juvenile condition of the structures might on occasion be maintained in individuals of either species otherwise adult, in which case some confusion of the two species might result, and may have resulted.

A very considerable degree of variation may be observed in the figures of the petasma of the two species offered by various authors, which is perhaps due in part to an insufficient understanding of the structure of the organ. The endopods of the petasma of *Metapenaeus* are equivalent to endopods of a simple open petasma such as that of *Penaeus* in which the lateral parts have become folded mediad across the ventral faces of the endopods nearly to the median line. The laterodistal corner of the external margin of each half of the petasma

is produced as a short trough-like horn (the distolateral lobe) open along its distal surface. The distomedian lobe has the form of a projecting flap of the dorsal side of the endopod between the median cincinnulated margin and the distolateral lobe. This flap bends over ventrolaterally, partly overlapping the distolateral and distoventral portions of the petasma. The distomedian lobes are short and simple in the immature male, but may with growth so increase in size as to quite conceal the lateral horns in ventral view. Such an hypertrophy of these lobes is peculiar to the genus although a somewhat similar condition occurs in a few species of *Parapenaeopsis*.¹ In various figures and descriptions of the petasma of *Metapenaeus*, the distomedian lobes have not been indicated to be free from those parts which they merely hood. It is probable that the differences between various figures of *M. monoceros* or *M. affinis* represent not only true variation in the size and shape of the flaps with age, locality, or individual, but in considerable part merely reflect differences of little real significance in folding or placement of the fleshy, unsupported lobes. So far as can be determined from available material, the principal difference in petasma between the two species under consideration lies in the fact that in *P. affinis* the distomedian flap is deeply crenellated along its distolateral margin, while in *M. monoceros* it is here entire. In none of my material of the latter form do the flaps rise so high above the lateral horns before folding over ventrally as in the figures by De Man, 1911, and Kishinouye, 1900.

The thelycum of *M. monoceros*, and probably also of *M. affinis*, seems subject to considerable change with age (see Schmitt, 1926a), but is probably fairly distinct in adults of the two species. Kishinouye's figure of this structure in *M. affinis* differs so considerably from the figures by De Man, 1924, and Alcock, 1906, as to make doubtful a reference merely to age differences.

In both *M. affinis* and *M. monoceros*, as in other species of *Metapenaeus* in which their presence has been denied, the lateral margins of the telson are armed with a series of mobile spines. These are very small and numerous in the above two species, lying inconspicuously along the dorsolateral margin above the sharp edge beneath which the cilia are rooted. An intergrading series of conditions may be found, through *M. joyneri* and *M. brevicornis*, to the *M. ensis* group in which certain spines at the distal end of the series are so much enlarged as to be very conspicuous.

***Metapenaeus monoceros* (Fabricius)**

Penaeopsis monoceros, DE MAN, 1924; SCHMITT, 1926a; MONOD, 1930.

1 male, carapace length 20 mm; 3 females, carapace 12.5 to 25 mm. *B.O.C.* 46. Singapore, Straits Settlements, February, 1933.

2 males, carapace 16.5 mm. *B.O.C.* 49. Georgetown, Penang, February, 1933.

¹ In the new genus *Protrachypene*, discovered after the foregoing was written, and described below, very similar flaps occur.

1 male, carapace 19 mm; 1 female, carapace 26 mm. *B.O.C.* 48. Port Swettenham, Selangor, February, 1933.

1 male, carapace 19 mm; 2 females, carapace 12 and 15 mm. *B.O.C.* 47. Port Said, Egypt, March, 1933.

In addition to this material, a male 9 mm in carapace length from Hong Kong, and a male 15 mm and female 18.5 mm in carapace length from Amoy, China, in the collection of the American Museum of Natural History, were available.

The minimum total length of the females examined was 57 mm, the maximum 123 mm. None were impregnated. The smallest male was 43 mm, the largest, 100 mm. The largest male with the copulatory endopods not hooked together was 95 mm in total length.

This species, and the following one, appear to be recent migrants to the Mediterranean by way of the Suez Canal (Balss, 1927).

***Metapenaeus stebbingi* Nobili**

Penaeopsis stebbingi, TATTERSALL, 1921; MONOD, 1930.

Not *Penaeopsis stebbingi*, SCHMITT, 1926a.

1 male, 2 females. *B.O.C.* 40. Port Said, Egypt, March, 1933.

Schmitt, 1926a, is right to compare the thelycum figured by Balss, 1914, as *Penaeopsis mogiensis* (Rathbun) juvenile with that figured by Tattersall under the name of *Penaeopsis stebbingi*. It is obvious, however, that the numerals of Tattersall's figures have been misplaced, and that the thelycum numbered as *M. stebbingi* actually represents that of *Penaeopsis vaillanti* Nobili, and vice versa. Balss' specimen is evidently to be referred to *P. vaillanti*. Schmitt's statement that Balss' figure is nicely fitted by the original description of the sternal armature and leg base spines of *M. stebbingi* does not accord with my interpretation of Nobili's statements, since Balss depicts a conspicuous pair of sternal spines between the second legs and the third legs as unarmed, characters impossible to *M. stebbingi* or indeed to any other known species of *Metapenaeus*.

Tattersall's figure 10 of the petasma of *M. stebbingi* is sufficient for recognition. His figure 12, although incomplete, may serve for identification of the thelycum. The median plate of sternite XIII in the present species is short and inconspicuous, and is placed close beneath the overhanging lateral hoods of sternite XIV; the structure is, although described by Nobili, 1906, omitted both from his figure and from that of Tattersall.

The mobile spinules of the lateral margins of the telson of *M. stebbingi* are minute, but larger and less numerous than are those of *M. monoceros* and *M. affinis*.

***Metapenaeus brevicornis* (H. Milne Edwards)**

Penaeopsis brevicornis, DE MAN, 1924.

52 males, immature, total length, 45 to 75 mm.; 43 females, immature, total

length 45 to 75 mm.; 1 female, adult, total length 100 mm. *B.O.C. 51*. Singapore, Straits Settlements, February, 1933.

3 males, adult, total length 80 mm.; 1 female, adult, total length 90 mm. *B.O.C. 50*. Georgetown, Penang, February, 1933.

The differences between the adults of this species and of *M. lysianassa* (De Man) have been well described by De Man, 1887 and 1924, and Alcock, 1906. In young individuals of the two species, however, the differences are much slighter. The rostrum of *M. brevicornis* becomes with decreasing size of the individual nearly as short as that of *M. lysianassa*, in which last the rostrum seems to change its proportionate length very little with change in size. The expansion of the ischium of the fifth legs characteristic of the adult female of *M. lysianassa* is not discernible in juveniles; and the thelycum is sometimes quite similar in young individuals of both.

A difference between the species in armature of the telson, described for adults by De Man, 1924, is unchanged by age, and diagnostic. It may be noted that in addition to the pair of spines near the distal end of the telson in *M. brevicornis*, there is a proximal series of very much more minute spinules overlooked by De Man. The difference between this armature and that of *M. lysianassa* therefore lies in the fact that in the latter the lateral spines regularly enlarge from proximal distad; while in *M. brevicornis* there is a sudden increase in size affecting the last one or two spines.

M. brevicornis possesses an ischial spine on the first legs, which is sometimes quite small, but never absent. In *M. lysianassa* the ischial spine is usually lacking, but is occasionally present.

The thelyca of very young females of the two species are usually distinguishable in that the entire median plate is distinctly embossed upon the sternum of *M. lysianassa* even at a carapace length of 8 mm., whereas its anterior portion is usually not developed in females of *M. brevicornis* of carapace length less than 15 mm. The entire median plate is, however, occasionally developed in the latter, when the immature thelyca appear somewhat alike.

There are slight differences between young as well as adult females of the two forms in the shape of the coxal projection of the fifth legs, that of *M. brevicornis* being incised, that of *M. lysianassa* entire. The basal portion of the outer margin of the exopod of the uropod of adult males of *M. brevicornis* is somewhat emarginate.

The difference noted by De Man between the petasma of his males of *M. brevicornis* and that figured by Alcock and by Lanchester, appears to be dependent on age. Among the numerous Singapore males examined the petasma of the largest (carapace length 15 mm.) had more divergent lateral horns (DISTOLATERAL LOBES), and filaments (appendages of the short DISTOMEDIAN LOBES) attached nearer the middle of the distal margin than in the smaller specimens, which resembled De Man's figures. Three large Georgetown males (carapace length more than 16 mm.) had divergent cornua and filaments

attached in the middle as in Alcock's figure. It seems probable that the change in petasma occurs quite suddenly, at a total length of about 75 mm. The length and shape of the filaments is variable. These structures are equivalent to much narrowed flaps of the sort found in the *M. affinis* group.

In *M. brevicornis*, and probably in *M. lysianassa*, as to a greater degree in the nearly related pair, *M. dobsoni* (Miers) and *M. joyneri* (Miers), the basal spine of the third leg of the male is larger than that of the female. There seems to be a remarkable parallelism between thelycum and petasma in these two pairs of species. In *M. brevicornis* and *M. joyneri*, where the petasma has conspicuous free distal filaments, the lateral hoods of the thelycum are widely separated by the posterior part of the median plate; while in *M. lysianassa* and *M. dobsoni*, the petasma of which is not reported to bear free filaments, the lateral hoods of the thelycum meet in the median line for part of their length.

In a male and a female of *M. joyneri* in the collection of the Department of Zoology of the Peabody Museum of Natural History, the telson possesses a lateral armature very similar to that of *M. lysianassa*. The peduncle of the uropods of the male of this Japanese species, an individual about 83 mm. in length but probably only semimature, does not differ from that of the female; there is no tooth like expansion of the merus of the fourth leg; the meral tooth of the fifth leg is very small; and the enlarged basal spine of the third leg does not reach to the end of the ischium and does not have an expanded tip.

The thelycum of *Metapenaeus brevicornis* is typical of the genus. The transverse groove serves as sperm receptacle, without an especial cavity being formed from it by the deep invagination of a limited part of the groove such as occurs in *Parapenaeus*, *Trachypeneus* or *Eusicyonia*. The thelycum of *Metapenaeus* differs conspicuously from that of the American species of *Metapenaeopsis* only in that the transverse groove is continuous across the midline; this difference is not a clearly significant one, since the character varies from genus to genus within the same series, and even within genera, as in *Trachypeneus*.

In the two large impregnated females of *M. brevicornis* the ventral surface of the thelycum is hidden beneath a pair of large white conjoined pads of non-sperm-bearing material deposited by the male. To the middle of the dorsal surface of the pair of pads is attached a plug of yellow horny material continuous with the posterior end of the investiture of the spermatophores contained in each half of the transverse groove. Upon removal of the white pads, the subrectangular anterior part of the expanded median plate of sternite XIII, lifted above the sternal surface by a narrow longitudinal support, may be seen to be continued posteriorly as a broad elevation, emarginate posteriorly and overlapped on the sides by the lateral hoods of sternite XIV. From the posterior portion of sternite XIV the lateral hoods extend forward on either side to disappear beneath the expanded anterior portion of the median plate of XIII. Between the median anterior margin of the portion of XIV which rises laterally into the lateral hoods, and the concave median posterior margin of the posterior

part of the median plate of XIII, there is a gap from which the plug of yellow male secretion mentioned above protrudes. This gap evidently serves as entrance to the sperm cavities.

Dissection reveals that the transverse groove runs anterolaterally on each side from its exposed posteromedian section, between the narrow basal support of the median plate and the median margins of the lateral hoods. The lateral hoods lap over the posterior part of the median plate, and are overlapped by its anterior part, beneath which the much expanded transverse groove is concealed. Each of the sperm receptacles thus enclosed opens anterolaterally just behind the level of the fourth leg bases, at which point the lateral hoods are terminated. Both lateral cavities are filled with sperm embedded in a clear yellow matrix. The broad anterior exits of the cavities are blocked by the expanded coxal projections of the fourth legs. Across the anterior surfaces of the sperm masses scratches are perceptible which appear to have been made by movements of the spines set on the coxal projections. It is probable that the two spermatophores are inserted by the male through the posterior opening, which is then stoppered with a plug of the yellow material; and that the mass breaks up at the time of oviposition, when the sperm ooze out of each anterior opening to be swept forward by movements of the fourth leg bases. Such a process has been observed in *Penaeus trisulcatus* by Heldt, as mentioned with reference to *Penaeus brasiliensis* in the preceding paper.

The function of the pair of white externally applied pads is uncertain, and it may be noted that in the impregnated female of *M. lysianassa* available to me these structures were set on very much askew. The spermatophores, including the pads, are completely preformed in the male, one of the pair lying in the enlarged distal end of each vas deferens. The distal end of the vas in *Metapenaeus* seems very similar to the same structure in *Penaeus*. The white pads are perhaps rudimentary homologues, as suggested by Kishinouye, of the appendages of the spermatophore of *Penaeus*, which have been shown in the preceding paper to function for attachment of the exposed spermatophores in peneids with open thelycum.

***Metapenaeus lysianassa* (De Man)**

Penaeopsis lysianassa, DE MAN, 1924.

1 male, about 40 mm total length; 9 females, 40 mm juvenile to 85 mm adult with spermatophore. *B.O.C.* 45. Singapore, Straits Settlements, February, 1933.

1 female. *B.O.C.* 43. Georgetown, Penang, February, 1933.

1 cephalothorax. *B.O.C.* 44. Port Swettenham, Selangor, February, 1933.

***Metapenaeus intermedius* variety *anchista* (De Man)**

? *Penaeus monoceros ensis*, DE HAAN, 1850.

? *Penaeus intermedius*, KISHINOUE, 1900.

? *Metapenaeus ensis*?, ALCOCK, 1906.

Penaeopsis ensis, BALSS, 1914.

Penaeopsis intermedia anchista, DE MAN, 1922.

? *Penaeopsis endeavouri*, SCHMITT, 1926a.

1 male, semimature, total length 104 mm. *B.O.C.* 41. Port Swettenham, Selangor, February, 1933.

In addition to this specimen, an immature male from Singapore of total length 83 mm, in the collection of the Department of Zoology of the Peabody Museum of Natural History; and an adult female of 145 mm total length from Hong Kong, in the collection of the Museum of Comparative Zoology at Harvard, were available for examination.

Four named species, certainly very closely related, may be termed the *M. ensis* group. These, *Penaeus monoceros ensis* De Haan from Japan; *P. intermedius* Kishinouye from Japan, *Penaeopsis intermedia anchista* De Man from the East Indies, and *P. endeavouri* Schmitt from Queensland, Australia, are all rather uncommon, and extensive comparisons have not been made. The diagnostic distinctions between the forms seem somewhat uncertain.

Kishinouye, 1900, fails to consider the relationship of his *M. intermedius* to *M. ensis* (De Haan), which latter, like De Haan, he compares with *M. monoceros*. No material resembling the figure by Kishinouye in the characters of horizontal rostrum and large anterior pair of lateral telson spines has since been reported.

De Man, 1920, has proposed a varietal name, *M. i. anchista*, for East Indian specimens with elevated rostrum, short anterior pair of telson spines, and short posterior pair of telson spines. At the same time, De Man has prepared, from the notes of another observer upon the type of De Haan's species apparently made without direct comparison with East Indian material, a list of the diagnostic differences between *M. ensis* and *M. i. anchista*. It may be observed that *M. ensis* is reported to resemble *M. i. anchista* and to differ from Kishinouye's figure of *M. intermedius* in the two chief characters supposedly distinguishing the latter two forms, its elevated rostrum and small anterior pair of telson spines. The differences between *M. ensis* and *M. i. anchista* are stated to be as follows: the third pleonic somite of *M. ensis* bears a median dorsal carina; a carina extends from the hepatic spine to the posterior border of the carapace; the ischial spine of the first cheliped is much shorter than the basal; and the posterior of the three pairs of lateral telson spines is longer than in *M. anchista*. In the last of these characters, De Man notes that *M. ensis* resembles Kishinouye's figure of *M. intermedius*. In the other characters, De Man seems to assume that *M. intermedius* differs from *M. ensis* in the same way as does *M. intermedius anchista*: but it may be observed that there is no available information about Kishinouye's form which might serve as basis for this assumption.

Schmitt, 1926a, has added some confusion to the case by attributing, without explanation, three specimens the geographical derivation of which is not men-

tioned to *M. intermedius*; while at the same time, he both states that he has not seen De Man's *M. i. anchista* and refers the Singapore specimen described (as *M. ensis*) by Balss, 1914, which is certainly identical with De Man's specimens, to *M. intermedius*. In attempting to find the reasons which led Schmitt to consider his specimens as relating to Kishinouye's rather than to De Man's form, it was observed that in comparing this material with *M. endeavouri*, Schmitt fails to mention any differences between the former specimens and the Australian material in rostrum, figured for the latter as ascending; and in telson, figured for the latter as with a small anterior pair of lateral spines. Therefore, in the characters considered by De Man as diagnostic of *M. i. anchista*, Schmitt's material seems to agree with that form, and not with *M. intermedius* with which it is identified. Schmitt's reference of Balss' East Indian specimen to the Japanese name seems to preclude the possibility that geographical considerations have influenced his determination, the basis for which is therefore not apparent.

Summarizing the above complex situation, if *M. i. anchista* De Man is not certainly distinct from *M. intermedius* Kishinouye, it is simultaneously true that *M. intermedius* has not been shown to be distinct from *M. ensis* De Haan in the characters reported to distinguish the latter form from *M. i. anchista*. I am inclined to believe that the differences between Kishinouye's figure and other known specimens of the group in rostrum and telson are of doubtful significance; and that the differences reported between the type of *M. ensis* and other known specimens in pleonic carina and cardiaco-branchial carina need confirmation.

M. endeavouri (Schmitt) 1926a, is described as differing from Schmitt's *M. "intermedius"* by its larger size; its more pubescent carapace and pleon; its thelycum without a posterior median tubercle, with an emarginate rather than convexly projecting anteromedian margin of the median plate and with the lateral plates not bent at right angles in the middle; the smaller size of the coxal projections of the fourth legs of the female; and the presence of a small spine-like projection mediad the distolateral projection of its petasma, which lacks the "small point on the outer proximal margin," and has a different "protuberance of the inner distal angle" and of the "proximolateral angle" of the distal end. The telson armature of *M. endeavouri*, not described by Schmitt, is figured by him as consisting of only two pairs of lateral spines instead of three. This is probably an error.

The figure of the thelycum of a small East Indian female by De Man, 1922, a description expanding that by De Man, 1920, and evidently overlooked by Schmitt, seems not to be accurate in detail. This figure differs from that of a larger East Indian female by Balss, and resembles Schmitt's Australian form, in lacking the posteromedian tubercle; while it resembles Balss' figure and differs from Schmitt's in the convex anterior margin of the median plate, and is intermediate in the length of the coxal projections of the fourth legs. De

Man fails to refer to Balss' note. The figure of the petasma by De Man, 1922, is that of a quite immature male.

The three specimens of the *M. ensis* group at my disposal, from Singapore and Hong Kong, seem to pertain to a single species. In all, the third pleonic somite completely lacks a carina. The female has a blunt but conspicuous sulcus-bordered carina extending as far as the anterior two-fifths of the fourth pleonic somite; in the two males this carina extends only to the middle of the segment. The carapace lacks a crest between the hepatic buttress and the posterior border, but it may be noted that a prominent cardiaco-branchial ridge borders the setose sulcus ventrally, and although it does not reach anteriorly to the hepatic buttress, is connected with it by a convex area channeled only by a short transverse sulcus. The rostrum of all three specimens ascends at an angle of about ten degrees, the tip being straight or a little upturned; and reaches beyond the base of the third segment of the antennular peduncle. In the two males the armature is $\frac{10 + 1}{0}$; in the female, $\frac{9 + 1}{0}$. Only one tooth besides the epigastric, in contradiction of De Man's figure and description, stands behind the orbital margin.

In the two males, the anterior lateral spine of the telson is less than two thirds the length of the posteriormost one; and the posteriormost reaches less than halfway to the tip. In the large female, the anterior spine is relatively longer, about three fourths the posterior, and the telson tip is somewhat shorter and slenderer than in the Singapore specimens. It may be noted that a band of minute spinules accompanies the enlarged spines. It is evident that these specimens correspond to those regarded by De Man as *M. i. anchista*.

The pubescent areas of the integument of the three available specimens seem subject to increase in extent as well as in density of ciliation with increase in size of the individual. In the two smaller specimens the patches on the second, third and fourth pleonic pleura range up to one-fourth the length of the pleura, while in the larger Chinese female, these patches occupy over two fifths the length of the pleura. The branchial region of the carapace, naked in the smaller specimens, displays three conspicuous pubescent areas in the large one: a long ventral longitudinal stripe and two shorter dorsal patches beneath the cardiaco-branchial ridge.

The thelycum is essentially similar in structure to that of *M. monoceros* (Fabricius). In the present specimen it bears a conspicuous posteromedian ridge or tubercle, as described by Schmitt for his "*P. intermedius*," which he appears to consider identical in female genital apparatus with the Singapore female examined by Balss. However, as in *M. endeavouri*, the Chinese specimen has a median notch at the anterior margin of the median plate, rather than a convexity. It is possible that the convexity shown in figures by Balss and De Man actually refers to the anterior part of the ridge upon which the expanded median plate is supported, rather than to the anterior margin of the plate itself.

The coxal projections of the fourth legs of the Chinese female are long, and the lateral plates are bent at right angles in the middle.

The petasma does not completely coincide with Schmitt's description of his "*P. intermedius*." The smaller spine mediad the distolateral projection, stated to be present in *M. endeavouri*, absent in *M. "intermedius,"* is present in the fairly mature male of the present report. Differences postulated between the Australian form and *M. "intermedius"* in length of "protuberance of the inner distal angle" and shape of the "proximolateral angle of the terminal portion" are certainly of doubtful significance. These characters refer to the flap-like projection of the mediodistal lobe, which bends over ventrolaterally as in *M. monoceros*, hooding the ventral margin of the petasma. This structure in other species of *Metapenaeus* is quite variable, especially with age; the difference in size between Schmitt's Australian material and available northern males would probably be sufficient to account for some structural diversity. In the mature male available to me the distolateral projection overtops the distomedian lobe, as in *M. endeavouri*, but not in the northern material reported by Schmitt.

It seems from the above that the diagnostic value of some differences between *M. endeavouri* and northern forms postulated by Schmitt cannot be completely confirmed, although there appear to be several real differences. I do not believe that the disparities between my material and Schmitt's description of specimens which he refers to *M. intermedius* signify that a real difference in petasma and thelycum between Schmitt's material and De Man's *M. i. anchista* actually exists. It is of interest that the Chinese female, nearer the Australian specimens in size than any previously recorded northern specimens of the *ensis* group, shows a recognizable increase over smaller specimens in the density and area of pubescence.

Although it is probable that several species may actually exist within the *ensis* group, until range of variation and degree of geographical intergradation in the supposedly diagnostic characters are better known, and until the actual existence of some of these characters has been confirmed, the possibility that all named species of the group are synonymous with *M. ensis* De Haan must be considered.

TRACHYPENEOPSIS, NEW GENUS

Genotype, *T. mobilispinis* (Rathbun), Atlantic America. Other species of the genus, *T. richtersi* (Miers), Indopacific.

Definition—Penaeinae of the **Trachypeneus** series in which the thirteenth somite lacks a pleurobranch; there are no longitudinal and transverse sutures on the carapace; the antennular peduncle does not bear a parapenaeid spine; the maxillulary palp has a small distal lobe; all the pereopods bear moderately long and slender exopodites; both maxillipedes bear exopods; all of the epipodites are unfurcated; the basis of the first chelipeds only is armed with a spine;

and the telson bears three mobile lateral spines the distal of which is supported on a much produced basal shoulder.

The superficial resemblance of the species of this genus to *Penaeopsis* and to *Metapenaeus* has caused their confusion with the latter two groups. From both, *Trachypeneopsis* is readily separable by its different branchial formula and unfurcate epipods. From the former it is additionally distinguished by the lack of a parapenaeid spine and of a pair of fixed teeth distal to the mobile lateral spines of its telson. From the latter it further differs by the presence of an exopodite on the fifth legs, and the absence of a spine from the basis of the second and third chelipeds.

The absence of both longitudinal and transverse sutures distinguishes *Trachypeneopsis*, like *Metapenaeus*, from other members of the **Trachypeneus** series. The new genus appears to be most closely related to *Atypopeneus*, in which, however, De Man has found the transverse suture to be present. It is further distinguished from *Atypopeneus* by its buttressed antennal spine, its short antennular flagella, the reduced armature of the proximal segments of its chelipeds, the armature of its telson, its peculiar petasma, and probably by the lack of furcation of its epipods. This latter feature seems to be unique among adult Penaeinae, in which the epipods of VIII and XII at most, as far as is known, are unfurcate; and recalls the condition found in Aristaeinae and certain Solenocerinae.

Trachypeneopsis has been referred to in the preceding paper (Burkenroad, 1934) as the "first of three genera confused under the name '*Penaeopsis*'."

***Trachypeneopsis mobilispinis* (Rathbun)**

Metapenaeus mobilispinis, RATHBUN, 1919.

Material examined includes a female, 39 mm in total length, probably a cotype, very kindly loaned by the Rijks Museum van Natuurlijke Historie of Leiden; and a female of carapace 7.7 mm, total length about 34 mm, from Turks Island, Bahamas, discovered among recent accessions to the collection of the American Museum of Natural History. This second specimen represents the first record of the species since its description, and extends its range very considerably to the northward.

The close relationship between the Indopacific *T. richtersii* (Miers) and the Antillean species seems heretofore to have escaped attention. Differences between the Pacific species as described and figured by Miers, 1884, Rathbun, 1906, and De Man, 1911; and the latter seem extremely slight, and hardly worthy of notation without corroboration by direct comparison.

The following additions to the description of *T. mobilispinis* may be made:

Somite XIII bears, in addition to the posterior arthrobranch, a conspicuous unfilamentose vestige of an anterior one. The lobule on the posterior margin of the gill-bearing section of this somite is not ciliated. The "rudimentary

arthrobranch" (branchial lamella) of somite VII is filamentose. Epipods are present on the second maxillipedes and the first, second and third legs. The exopodites of the walking legs have a strong constriction in the middle, in addition to their basal joint. There is a basal spine and a very minute ischial on the first legs: the others are unarmed. The paired teeth of the posterior margin of sternite XI are no more conspicuous than in other members of the *Trachypeneus* series. The endopod of the first pleopod of the female is completely absent, as in the American species of *Metapenaeopsis* but not in *Metapenaeus*; those of following pleopods are unusually small. The eye reaches well beyond the internal antennular scale, instead of failing to reach its tip as stated by Rathbun. The proximal segment of the antennal peduncle bears a very elongate spine on its lateral margin. The anterior part of the lateral margin of the antennal scale does not bear minute spinules such as are present in the American species of *Metapenaeopsis*. The fourth pleonic tergum, like the fifth, is incised posteriorly; it is dorsally compressed but not carinate. Only the sixth somite bears a minute median spine at the posterior end of the dorsal carina. The lateral spines of the telson are much like those of the *M. ensis* group of *Metapenaeus*, but the basal shoulders on which the ultimate pair of spines is borne are much more elongated and the minute mobile spines scattered among the enlarged ones in the *M. ensis* group are absent in *T. mobilispinis*.

The petasma of *T. mobilispinis* as figured by Rathbun differs from that figured by her for *T. richtersii* (both figures being dorsal views) by the absence in the latter of a projection between the distolateral lobe and that figured as projecting proximal to it. Rathbun states, however, that two lobes instead of one are visible behind the median, terminal lobe in a ventral view of the petasma of *T. richtersii*. Ventral views of the petasma not being available, the homologies of the various projections cannot be determined. If, as is possible, petasma is constructed upon the same lines as that of *Metapenaeus*, a ventral view should indicate the distomedian lobes to be produced as free flaps bent down over the ventral surface; the distolateral lobes to be channeled like the lateral cornua of *Metapenaeus*; the intermediate lateral projections to be protuberances of the cornua, or possibly the exposed tips of the distomedian flaps; and the proximolateral projections perhaps to be merely exaggerated shoulder-like protuberances of the sides of the petasma.

The thelycum of *T. mobilispinis* agrees closely with that figured by Rathbun for *T. richtersii*. The "median acute spine" anteriorly "between the bases of the fourth legs and visible in that [Rathbun's] figure" which De Man states to be present in his specimen of *T. richtersii*, is absent in the female of *T. mobilispinis* examined. Moreover, I cannot find an indication of such a spine in Rathbun's figure referred to. There is, between the fourth legs, a high median longitudinal ridge projecting from the sloping anterior face of the median plate of the thelycum, but this ridge does not bear any trace of a spine in the adult Atlantic form although one is probably present in postlarvae. The antero-

median angles of the lateral plates of *T. mobilispinis* terminate in dentiform projections, as do those of *T. richtersii* according to De Man. The posterior continuum of the median plate of the thelycum bears in its middle a spiniform projection, somewhat as indicated in Rathbun's figure of *T. richtersii*.

Rathbun's description of the thelycum of *T. mobilispinis* is misleading; the "shallow concavity with uneven surface" is the median plate, lifted high above the general level of the sternite; the "low, curved smooth ridge" bounding the "concavity" on either side consists of the raised inner edges of the broad lateral hoods, elevated high above the sternal level. The lateral hoods embrace the median plate on its lateral margins, while posteriorly they merge with the posterior portion of sternite XIV. The large coxal nibs of the fourth legs overlap the lateral parts of the sloping anterior face of the median plate, and abut behind against the anterior margins of the lateral hoods. This thelycum seems quite similar to the type found in *Metapenaeus*, although without dissection it is impossible to ascertain that the posterior pair of openings between the median plate and the lateral hoods on either side of the median line, near the point where the lateral hoods merge with the remainder of sternite XIV; and the anterior pair of openings, between the foremost portions of the lateral hoods and the sides of the median plate, lead into a simple enclosed cavity like that of *Metapenaeus*.

No Pacific American congener of *T. mobilispinis* is at present known, but it is probable that one will be discovered.

PROTRACHYPENE, NEW GENUS

Only known species, *Protrachypene precipua*, new species, Pacific America.

Penaeinae of the **Trachypeneus** series. The thirteenth somite lacks a pleurobranch; there are both longitudinal and transverse sutures on the carapace; and the second maxillipede lacks any trace of an exopod.

The antennal carina and sulcus are well developed. The telson is armed with a series of eight or more minute mobile lateral spines. The antennular flagella are elongated. The third maxillipede and all the pereopods bear exopods. The epipods of the first and second legs are furcated, those of the third leg and second maxillipede entire. The fourth and fifth legs are immoderately long and slender, flagelliform; but with the joints entire, not subdivided. The chelae of the three anterior legs are extremely weak, with much lengthened palm and short fingers. The petasma has a flap on the proximal part of the dorsal walls of the spout-like distolateral lobes which is overlapped by the ventral wall of the spout instead of overlapping it. The transverse groove of the fourteenth sternite of the female is continuous across the segment but is not deeply invaginated in the midline; the sperm receptacles are formed by shallow lateral invaginations. The spermatozoa are not organized into numerous small spermatophores.

Protrachypene is of interest as resembling in certain respects the genus *Metapenaeus*, i. e., in the redundant lateral armature of the telson, and the flap of the dorsal walls of the petasmal cornua. Other characters—lack of a pleurobranch on the thirteenth somite, presence of longitudinal and transverse sutures on the carapace—indicate it to be very closely allied to *Trachypeneus*. In one important feature, the complete loss of the exopodite of the second maxillipede, *Protrachypene* is unique in its series, and is paralleled only by *Artemesia* and *Macropetasma* among Penaeinae; in both of the latter genera the exopods of five appendages posterior to the second maxillipedes are also absent, whereas in *Protrachypene* these rami are very well developed. Unique also are the peculiar chelae. The combination of other characteristics is not completely duplicated in any of the other genera of the series.

***Protrachypene precipua*, new species**

Figures 11 and 12, page 47.

1 male, 1 female, adult, types. *B.O.C. 106*. 64 males, 119 females, juvenile to adult, cotypes. *B.O.C. 107*. Bella Vista Beach, Panama City; seine; 9:00–12:00 A.M., February 9, 1934.

3 males, 4 females. *B.O.C. 108*. Bella Vista Beach, Panama City; cast-net; 9:00–11:00 P.M., February 9, 1934.

2 females (one impregnated). *B.O.C. 109*. Panama City Market (reported locality, Chame Point); February 10, 1934.

6 males, 11 females. *B.O.C. 110*. Panama City Market; February 12, 1934.

Dimensions—Type male, carapace 13.8 mm; rostrum, 16 mm; total, 75 mm. Type female, carapace 15.3 mm; rostrum 20 mm; total 88 mm. Size range in carapace length, male, 7–13.8 mm, female 6–15.3 mm.

Description—The branchial lamella of the seventh somite is filamentose. The thirteenth somite lacks any vestige of an anterior arthrobranch.

The rostrum is extremely long in adults, projecting far beyond the antennular peduncle; it is up to 2 mm longer than the carapace in males, and to 5 mm longer in females. At a carapace length of about 10 mm in males, 11 mm in females, the rostrum becomes shorter than the carapace, down to less than half as long as the carapace in the smallest specimens. The subcylindrical, styliform, unarmed distal portion of the rostrum of adults usually amounts to more than two-thirds of the whole. The rostrum has a pronounced sigmoid curve, although the terminal part is not strongly ascending. The rostral crest is armed above with 7 to 9, usually 8, teeth in advance of the epigastric, two of which are behind the orbital margin. The posteriormost two teeth are part of a crowded group of four, of subequal size, in advance of which are placed the remaining teeth, decreasing in size and at increasing intervals anteriorly. The anteriormost rostral tooth usually lies somewhat behind the level of the second segment of the antennular peduncle. The crest of the rostrum is high and lamelliform over the orbit, the depth of the dorsal serrations being relatively very slight. This

supracarinal crest completely disappears somewhat behind the anteriormost tooth, at which point the lateral carinae reach the dorsal margin and are terminated.

The epigastric tooth is placed in advance of the level of the hepatic; the lateral ridge of the rostrum disappears before reaching it. The postrostral carina is distinct almost to the posterior margin of the carapace.

The orbital angle forms an obtuse tooth. The antennal and hepatic spines are well developed. The anteroinferior angle of the carapace is slightly produced. The cervical sulcus is shallow, setose, and indistinct, without an accompanying carina; it extends to only slightly above the level of the longitudinal suture. The cardiao-branchial sulcus and carina are extremely strong. Anteriorly the cardiao-branchial merges with the anterior cervical, which runs straight toward the antero-inferior angle but falls far short of reaching it. The antennal sulcus and carina are well developed.

The longitudinal suture reaches very little, not a fifteenth of the carapace length, behind the anterior margin; and thus falls far short of the hepatic spine. The transverse sulcus is faintly marked but present, at the level of the third legs.

The posterior pereionic tergum is hardly set off from the anterior pleonic tergum, save by absence of pubescence. There is a low middorsal longitudinal ridge on the first three pleonic somites, a sharp carina on the last three, in each of which it terminates in a small tooth. The sixth pleonic somite has a strong, slightly arched, longitudinal lateral carina, which is continued on the sides of the fifth somite as a $\wedge$ -shaped ridge.

The telson is long, slender and acuminate, without any sudden narrowing behind the distalmost lateral spines. Its lateral armature consists of 8 to 15 pairs of rather irregularly placed mobile spinules set just dorsal to its ventro-lateral margin. The distalmost three to six pairs are occasionally perceptible even to the naked eye, but the increasingly minute proximal spines are difficult to make out. The distalmost pairs are set upon fairly well developed acetabula. The spines are all well spaced; they run from one-ninth or more posterior to the proximal shoulder, to within one-seventh of the tip.

The dorsal and lateral surfaces of the entire animal, with the exception of the rostrum and postrostral carina, the antennal, anterior cervical, and cardiao-branchial sulci, the pleonic dorsal and lateral carinae, the posterior pereionic tergum, and a few other small patches on carapace and pleon, are covered with a fairly dense, short pubescence.

The general form, with rather slender cephalothorax and relatively deep pleon, is somewhat similar to that of *Metapenaeus brevicornis*.

There is no parapeneid spine on the inner margin of the basal segment of the antennular peduncle, similar to other members of the series. The internal scale of the first segment of the antennular peduncle has a truncated tip. The superior antennular flagellum is long and slender, the basal part being little enlarged; it is a third or less longer than the carapace, and somewhat less than

twice as long as the inferior flagellum. The antennal scale reaches well beyond the antennular peduncle. The antennal peduncle is very long, reaching to beyond the first segment of the antennular peduncle.

The terminal lobe of the maxillary palp is present but very short; its medio-distal lobe is armed with a single strong spine; and the posterior surface of the main portion with a longitudinal row of four stout spines. The maxillary palp has three strong spines on its anterior distal face, in addition to the posterior tooth, and the row of spinules on the median margin. The propodus of the second maxilliped is peculiarly produced at its proximolateral corner, into a high subtriangular projection. The exopod of the third maxilliped reaches to near the end of the carpus; while that of the second maxilliped is completely absent.

The basis of the first cheliped is armed with a long and slender spine; that of the second with a minute protuberance, or, often, spine; the ischium of the first leg is produced at its inner distal angle into a large triangular tooth; the other legs are unarmed. All three chelipeds have in the adult an extraordinarily long and slender palmar part of the propodus, with very weak, short, straight fingers. The fingers of the third leg may measure little more than a fourth of the palm in length, while the chela is nearly three-fourths as long as the carpus, and more than ten times as long as broad. In juveniles the chelae are of normal form, with strong fingers more than half the length of the palm. All the chelipeds are slender; the third extend beyond the middle of the second joint of the antennular peduncle, but fall short of the end of the third; the second beyond the first joint; the first legs not to the middle of the first antennular joint. The entire median margin of the first chelipeds, ischium through dactyl, bears long, thickly set setae, while the second and third legs are similarly setose on carpus and chela. The fourth and fifth legs are very long, extremely slender and fragile, and are complete in very few of the available individuals. The fifth legs overreach the antennular flagella, the fourth legs to two-thirds the propodus of the fifth. The merus, carpus, and propodus of the fifth legs are subequal in length and about twice the ischium. The tip of the unjointed dactyl of the fourth legs is styliform; that of the fifth legs was not present in material examined. The fourth and fifth legs are sparsely set with scattered setae. The pereopodal exopods are long, slender and thin, not broad and fleshy as in *Trachypneus*.

The first pleopods of the female lack any vestige of an endopod, although the notch from which these rami spring in some Penaeinae is present. The second pleopods of the male bear an appendix masculina consisting of a short stalk topped by a rather large subrectangular structure strongly troughed on its posterior face, and with the margins closely set with short spinules.

The petasma resembles that of *Trachypneus* in general appearance. The cornua terminate in a slender beak curved proximad and turned out of the lateral plane in a ventral direction. Below the bases of this beak the cornua expand to form a rounded projection. The ventral walls of the cornua overlap

the dorsal ones. The anterior portions of both walls, externally, are scabrous. Mediad a small projection surmounting the anteromedian margin of the endopod, equivalent to the vestige of a distomedian lobe in *Trachypeneus*, the dorsal wall of either distolateral spout gives rise to a subrectangular flap which bends over anteriorly to lie in the channel of the spout. This flap seems to be equivalent to the lateral parts of the hypertrophied distomedian lobe in *Metapenaeus*, in which the flap is continuous to the cincinnulated median margin

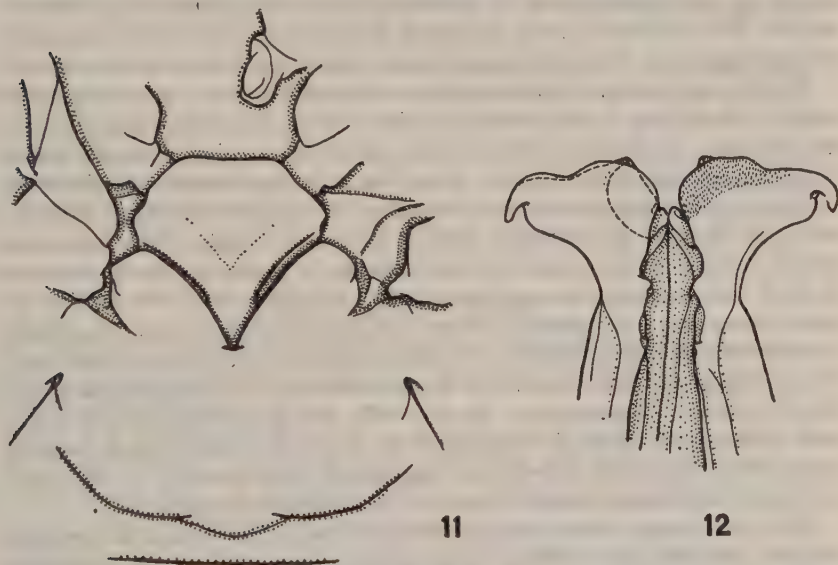


Figure 11. *Protrachypene precipua*, n. gen. and sp.
Thelycum $\times 10.5$.

Figure 12. *Protrachypene precipua*, n. gen. and sp.
Petasma, distal portion, somewhat distoventral view $\times 10.5$.

of the endopod, and not separated by a notch from a lobe surmounting the median margin as in *Protrachypene*.

The median plate of the thelycum bears some resemblance in outline to a clover-leaf, although the anteromedian and the lateral convexities, always shallow, are sometimes not perceptibly isolated. Some distance medioposterior to either lateral convexity of the median plate, a sulcus appears which runs posteromedial parallel to the margin of the narrowing neck of the plate. These sulci, which appear to form the entrance-grooves of the thelycum, and which are separated by the lamelliform margins of the median plate from the exit-channels of the sperm receptacles, are unique. The arrangement may be compared with the somewhat similar device for separating entrance and exit of the sperm

receptacle in the first Division of *Trachypeneus*, where the middle portion of the transverse groove is deeply invaginated to form a commodious chamber into which the sacciform sperm receptacles open, the exit-channels being cut off from the median chamber by their position laterodorsad the elevated median plate. The mode of separation of entrance and exit in *Protrachypene* may also be compared with that in *Metapeneus*, where it is effected by the elimination, as in *Peneus*, of functional exit-channels. The entrances are in *Metapeneus* placed at the posterior ends of elongated sperm receptacles lying between median plate and lateral hoods, which are really equivalent to the exit-channels of *Trachypeneus* or *Protrachypene*, and at the anterior ends of which the exits lie.

The lateral hoods of *Protrachypene* run rather far forward, as inconspicuous slightly raised areas, to the anterior margin of the median plate, where the exits are situated. At the level of the widest part of the median plate, the lateral hoods are conspicuously elevated. From this point their median margins slope backward and inward to meet in the midline, leaving a V-shaped gap between, which is filled by the posterior part of the median plate. The transverse groove between median plate and lateral hoods is continuous across the apex of the V, but is not deeply invaginated there. On either side of the midline the transverse groove is invaginated to form the sperm receptacle proper, a vertically flattened trough-shaped chamber with concave dorsal and convex ventral floor. The posterior part of the receptacle is not expanded into a large sac as in the first Division of *Trachypeneus*. By the baffle and gutter arrangement of the edge of the median plate, the entrance of the receptacle is forced to its postero-median end, while the exit-channel commences anterolaterally at the point where the less elevated anterior portion of the lateral hood takes rise.

The lateral margins of the lateral hoods are notched at the level of the posterior edges of the fifth legs. Behind these notches the surface of the fourteenth sternite is unsculptured except for a shallow U-shaped sulcus near its posterior margin.

In the single impregnated female, a plate of sperm-free male secretion projects from the apex of the V-shaped gape between the lateral hoods, its posterior end being implanted in the shallow median portion of the transverse groove.

Dissection of the male reveals an interesting intermediacy of genital structure between that of *Trachypeneus* and *Metapeneus*. The elongated upper portion of the vas deferens is balled together in a much convoluted mass, as in *Trachypeneus*, but there is no spermatophore-sheath-secreting gland, and the sperm are not aggregated into encased bundles. The middle portion of the vas is tubular, without typhosole, as in *Trachypeneus*. In the enlarged lower end of the vas occurs a mass of sperm apparently not enclosed or embedded in any sort of sheathing. In the glandular evagination of this lower part of the vas is found a plate of sperm-free material, evidently that affixed to the median plate of the female. The spermatozoa are elongated cylinders swollen at either

end and with a slender spike-like projection at one end. The orifices of the vasa deferentia are subcoxal.

The juvenile individuals show no striking nonsexual changes save the shortening of the rostrum and the normal form of the chelae. In juvenile females, the rudiments of the complex transverse groove and lateral hoods of the adult appear, as is usual, in the form of a slightly arched transverse sulcus with a raised posterior lip, somewhat in advance of the middle of the fourteenth sternite.

The striking superficial resemblance of *Protrachypene* to young *Xiphopeneus*, in company with which it was taken, is noteworthy.

The color in life was translucent, with chromatophores not producing pronounced pattern save for a double transverse rusty band across the posterior dorsal surface of the pleonic somites.

Protrachypene seems to be one of the most abundant of Panamanian peneids at the season and locality of enquiry. It was not included in market samples obtained three months earlier in the year, but the size of the animal is so slight that it is culled from the catch by the fishermen and brought to sale only by accident.

TRACHYPENEUS Alcock

No member of the genus has heretofore been recorded from the American Pacific. The three species from this area described below are all members of Division I of Burkenroad, 1934.

The second Division of the genus, completely limited to the Indopacific, is quite sharply distinct from the first one, and displays a close resemblance to *Parapeneopsis* Alcock. It seems desirable to give formal recognition as subgenera to these two Divisions of *Trachypeneus*.

Trachypeneus anchoralis (Bate), designated the genotype by Alcock, 1901, has been shown by Schmitt, 1926a, to be composed of two species. One, represented by Bate's figured male, is evidently a member of Division I closely related to *T. curvirostris* (Stimpson). The other, represented by Bate's figured female, is a member of Division II, since it is shown by Schmitt to lack epipodites on the first and second legs, and since, according to Bate's and Schmitt's figures, the thelycum seems to lack an unpaired median invagination. Schmitt restricts the name *T. anchoralis* to the component species which belongs to Division II. Accepting this usage, Division II, Burkenroad, 1934, may be regarded as the subgenus *Trachypeneus* s. s.

TRACHYSALAMBRIA,¹ NEW SUBGENUS

Genotype, *Trachypeneus* (*Trachysalambria*) *curvirostris* (Stimpson). Species chiefly American. Epipodites present on the first three pairs of legs; transverse

¹ Salambria, modern name of the Thessalian river Peneus, to which the river-god of the same name was autochthonous.

suture of the fourteenth sternite of the female invaginated in the midline to form an unpaired pocket.

SECTION 1, Burkenroad, 1934

***Trachypeneus (Trachysalambria) similis pacificus*, new subspecies**

1 male, 1 female, adult, types. *B.O.C.* 52. 27 males, carapace 6 to 11 mm, total length 27 to 50 mm; 57 females, carapace 8 to 25 mm, total length 36 to 99 mm, cotypes. *B.O.C.* 53. Pearl Islands, Gulf of Panama (Latitude 8/29/40 N, Longitude 78/52/30 W), 19 to 24 fathoms, March 31, 1926.

1 male, 22 females. Paratypes. *B.O.C.* 54. Concepcion Bay, Lower California, May 23, 1926.

In the characters by which the Atlantic *Trachypeneus similis* is distinguished from the Atlantic *T. constrictus*, which have been discussed in the preceding paper, *T. pacificus* agrees with the former; it possesses a postrostral carina distinct almost to the posterior margin of the carapace; a very pubescent sixth pleonic somite; a long slender terminal portion of the telson beyond the distalmost lateral spines, which tapers gently to the tip without an enlarged proximal portion; an antennal peduncle reaching well beyond the external scale of the base of the antennular peduncle; an exopod on the fifth leg not reaching to the distal end of the basis; a sculptured shield on the fourteenth sternite of the male, the posteriorly directed apex of which is not constricted off from its base; and a thelycum of which the anterior margins of the lateral and median plates are truncated rather than convexly produced, and the surface of which is naked instead of pubescent. In a further diagnostic character not mentioned in the preceding paper, *T. pacificus* resembles *T. similis* and is distinct from *T. constrictus*: On the ventrolateral surface of the sixth pleonic somite an arched longitudinal ridge occurs which is bordered above by a sulcus, and is carinated at one, or usually two points to produce cicatrices much like those of *Penaeus*. This ridge is absent in *T. constrictus*, although a faint trace of the sulcus is perceptible.

T. pacificus is distinguishable from *T. similis* only by its somewhat more pubescent sixth pleon; the larger penultimate spines of its telson, which are placed farther anteriorad the distalmost pair than in *T. similis*; the lack of a concavity at the middle of the anterior margin of the median plate of its thelycum, such as is usual in *T. similis* where this part of the margin, except rarely, slopes without sharp definition into the ridge extending forward from beneath the plate; the slightly oblique truncation of the anterior margins of the produced posterior lips of the transverse groove, which slope posterolaterally from their anteromedian angles; and the different shape of the posteromedian projection of the coxa of the fifth pereopods, which is usually somewhat rectangular in outline rather than triangular. The third chelipeds are modally somewhat longer than those of *T. similis*, the range beyond the antennal peduncle being from five-sixths of the propodus to one-half the carpus; whereas the usual reach

in *T. similis* is little more than the propodus beyond the end of the antennal peduncle.

In 17 specimens, 3 had seven rostral teeth not counting the epigastric; 2 had seven teeth plus an anterior vestige; 7 had eight teeth; 4 nine teeth; 1 ten teeth. The posterior tooth of the rostrum varies in position from behind to before the orbital margin. A vestigial unfilamentose anterior arthrobranch is present on somite XIII, as in all the American species of Division I but not in the Indopacific *Trachypeneus curvirostris* of the same subgenus. The branchial lamella of somite VII is filamentose. The third pleonic somite is dorsally compressed but hardly carinate; the second has two very faint short parallel longitudinal grooves in the middle of its tergum, but the space between them is not carinate. The anteroventral angle of the carapace is not rectangular, the ventral margin sloping downward from the angle, then turning backward.

The differences between the present form and its Atlantic relative, although extremely slight, are sufficient for ready recognition. Since it is improbable that any geographical area containing intermediates between the two forms exists, it seems proper to recognize these slight differences with a name. Whether or not the Atlantic and Pacific components of a congeneric pair should be considered specifically distinct seems a purely academic question, since all grades of differentiation, from no recognizable differences to very extreme ones, occur in the various pairs known to me. In the present case the differences seem to correspond in degree with those generally classed as subspecific.

As has been mentioned in the preceding paper, there is no known Pacific congener of the Atlantic species closely related to *T. similis*, *T. constrictus*. This difference seems correlated with the fact that *T. constrictus* has a more northern and eastern center of distribution than *T. similis*, and appears to be replaced by the latter in the regions of former communication between the American Atlantic and the Pacific. Further records of occurrence of the two Atlantic species are provided by the following catalogue numbers in the Bingham Oceanographic collection: *T. similis* (Smith): 55 and 56, Siguanea Bay, Isle of Pines, 12 fathoms, April 6, 1925, four females, [*T. constrictus* (Stimpson)] and "*Penaeopsis goodei* (Smith)," part, of Boone, 1927]; 57, New Providence, Bahamas, stomach of *Mycteroperca*, March 16, 1925, 1 subadult male [*Penaeopsis goodei* (Smith)," part, of Boone, 1927]; 58 and 59, Pensacola Bay, Florida, February and March, 1932, 2 males and eight females, all adult. *T. constrictus* (Stimpson): 87, off Matanzas Inlet, Florida, 8 to 10 fathoms, April 2, 1934, 1 male and 34 females.

***Trachypeneus* (*Trachysalambria*) *byrdi*,¹ new species**

Figure 13, page 54.

3 females, type and cotypes. B.O.C. 60. Panama City Market, December 8, 1933.

¹ Named for Mr. Junius Byrd.

Dimensions—Type female, total length about 185 mm; carapace 49 mm. Cotype females, total lengths 115 and 140 mm, carapace 27 and 33 mm.

Description—An unfurcate epipodite is present on the third leg and the second maxillipedes; a furcated one on the first and second legs. Branchial lamella of the seventh somite filamentose; an unfilamentose vestige of an anterior arthrobranch on the thirteenth somite. The basis only of the first and second legs is armed; the third maxillipede also bears a basial spine. The longitudinal suture of the carapace extends nearly to the posterior margin, far behind the conspicuous transverse suture. The posterior lip of the transverse groove of the thelycum is produced as a pair of free flaps; the median portion of the transverse groove is enlarged to form an unpaired pocket.

The rostrum of the type is broken and regenerating at the level of the fourth tooth. In the smaller cotype, the distal part of the rostrum is lost; the remainder, 19 mm long, extends beyond the tip of the antennular peduncle and bears eight teeth in addition to the epigastric, of which one lies behind the level of the orbital margin. The penultimate tooth lies above the distal third of the second segment of the antennular peduncle; the ultimate tooth, about one-half the size of the penultimate, lies over the middle of the third segment, and is one and one-half times as far from the penultimate as the latter from the antepenultimate. In the larger cotype the rostrum is 26 mm in length; the distal 10.5 mm is unarmed, and projects 7 mm beyond the antennular peduncle. There are seven teeth in addition to the epigastric; the position of the ultimate indicates it to correspond to the penultimate tooth of the preceding specimen.

The rostrum has a sigmoid curve, its base rising to a low crest of which the highest point is at the level of the first tooth in advance of the orbit; its middle portion slopes downward to a point at the level of the base of the second segment of the antennular peduncle, beyond which the distal portion turns strongly upward. The ventral lateral carina of the rostrum, which in other species of section 1 of the subgenus extends distally to beyond the sixth tooth, here fails to reach the fourth tooth, while the sulcus between this carina and the dorsal one is very shallow.

The postrostral carina is blunt but strongly marked to the posterior margin of the carapace; it is slightly flattened behind the epigastric tooth, and shallowly sulcate for a very short space at the point where the cervical sulcus would cross if continued.

The cervical sulcus disappears dorsally before attaining the level of the longitudinal suture. The portion of this sulcus which lies ventral to the hepatic spine is continued backward as a well marked cardiaco-branchial suture margined beneath by an obtuse but conspicuous ridge.

The longitudinal suture is generally bifurcated somewhat in advance of its posterior end; it reaches within two or three millimeters of the posterior margin of the carapace. The transverse suture is rather short but strongly marked; its upper portion is sloped somewhat to posterior of the vertical.

The carapace is finely punctate-pubescent over its entire dully-polished surface, most sparsely so on the posterior part of the branchial region.

The third, fourth, fifth and sixth pleonic somites are sharply carinated in the dorsal midline; each carina, including that of the third somite, ends posteriorly in a conspicuous small tooth. The second somite bears a weak carina on the posterior two-thirds of the tergum. The first somite is very faintly but perceptibly carinate in the dorsal midline; it is separated from the posterior pereionic tergum only by a very shallow sulcus indicating the line of fusion.

The lateral surface of the sixth pleonic somite bears an arched longitudinal ridge bordered above by an ill-defined sulcus. This ridge is raised at an anterior and at one or two posterior points into cicatrices such as are conspicuous in *Penaeus*. The sixth pleonic somite is very sparsely pubescent over its general surface, although two rather densely punctate longitudinal bands exist on each side of the tergum, one just lateral to the middorsal carina, the other further ventrad.

The rather short, regularly acuminate telson bears a dorsal sulcus flanked by a pair of carinae. The ridge lateral to the carina on either side, strongly marked in the other species of the section, is here obsolete. The lateral margins of the telson are completely unarmed.

The antennular flagella are subequal in length, and as long as or somewhat longer than their peduncle. The antennal peduncle extends from a third to two-fifths its length beyond the external scale of the basal segment of the antennular peduncle. The third maxillipedes reach about to the end of the antennal peduncle; their exopod reaches about as far as to the end of the meral joint of the endopod. The exopod of the fifth legs is very small, not over one-fourth the length of the large bladder-like exopods of the anterior legs. The first pleopods of these female specimens have a hardly perceptible vestigial endopod.

The median plate of the thelycum has a convex anterior margin extending free well anterior to its vertical support. The middle and posterior portions of the median plate are depressed. The posterior lip of the transverse groove of the fourteenth sternite is produced as a pair of semicircular flaps which overlap the posterior part of the median plate. The median longitudinal gape between these two flaps is quite short, not reaching more than halfway back to the level of the constrictions marking the bases of the lateral hoods. These constrictions are deeper than in related species. The surface of the thelycum is naked. In the impregnated, large, type female a clear yellow secretion was observed to protrude from the slit, evidently part of a sperm-free mass stored in a median pocket of the thelycum, as in other species of the subgenus.

In one of the characters described above, the presence of a tooth at the posterior end of the middorsal carina of the third pleonic somite, *T. byrdi* differs, so far as I am aware, from all other adult Penaeinae, Eusicyoninae, and Solenocerinae, and parallels certain Aristaeinae. In a second character, the absence

of armature on the lateral margins of the telson, *Trachypeneus byrdi* differs from other species of the genus; in this lack it resembles certain species of the related genus *Parapeneopsis*, which are without a telson armature among forms in which it is predominantly present. In at least two characters, viz: the presence of a carina on all pleonic somites including the first, and the occurrence of teeth at the posterior ends of the middorsal carinae of pleonic somites in advance of the sixth, *T. byrdi* differs from the remainder of the subgenus. In spite of these



Figure 13. *Trachypeneus byrdi*, n. sp.
Thelycum $\times 5.5$.

divergences, the species seems to be properly a member of section 1 of the subgenus.

From the other two species of section 1, *T. byrdi* differs most conspicuously in addition to the above characters by its elongate sigmoid rostrum with styliform distal half and obsolescent ventral lateral carina; its well-marked cardiacobranchial ridge; its more extensive longitudinal fissure; the absence of a dense, stout, anteriorly pointing pubescence from the anterodorsal part of its carapace; the obsolete lateral ridge of its telson; its longer antennular flagella; its shorter third maxillipedes; the extreme minuteness of the endopod of the first pleopoda in its females; and its relatively enormous size. Its habitus is that of such a species of *Parapeneopsis* as *P. sculptilis*.

T. byrdi resembles *T. constrictus* more than it does *T. similis* in the convex anterior margins of median plate and paired flaps of the thelycum, and in the

failure of the slit between the flaps to reach as far posterior as the level of the notches of the lateral hoods, as well as in the sparse pubescence of the branchial region of its carapace and sixth pleonic somite. It resembles *T. similis* more than it does *T. constrictus* in the absence of pubescence from the surface of its thelycum; its strong postrostral carina; the conspicuous arched lateral ridge on its sixth pleonic somite; the extension of its antennal peduncle to considerably beyond the external antennular scale; and the degree of reduction of the exopod of its fifth leg.

In the preceding paper I have mentioned that the modern distribution of the two Western Atlantic species of *Trachypeneus* seemed to explain, on the assumption of its continuance from the past, the occurrence of a close congener of *T. similis* in the American Pacific, and the absence therefrom of a congener of *T. constrictus*. The discovery, since that discussion was written, of *T. byrdi*, a species clearly pertaining to the section of the subgenus erected to contain *T. similis* and *T. constrictus*, and somewhat resembling the latter species in the structure of its thelycum, necessitates a reëxamination of this hypothesis.

Upon careful consideration, it appears, first, that *T. byrdi* resembles *T. similis* more than *T. constrictus* in most of the characters distinguishing the latter two, and second, that *T. byrdi*, although more closely related to *T. constrictus* and the two subspecies of *T. similis* than to any others of the genus, is yet so remote from both that it cannot be regarded as forming one element of a bioceanic pair with either. It seems probable that the slight resemblance which the thelycum of *T. byrdi* bears to that of *T. constrictus* is not significant of a nearer relationship to that form than to *T. similis*, and therefore that the hypothesis of a significant correlation between the northeastern present center of distribution of *T. constrictus* and its lack of Pacific congener is not affected by the discovery of the new Pacific member of the section.

SECTION 2, Burkenroad, 1934

***Trachypeneus (Trachysalambria) brevisuturæ*, new species**

Figure 14, page 56.

The holotype, a male taken at Acajutla, El Salvador in April, 1866, by Mr. F. H. Bradley, is in the collection of the Zoology Department of the Peabody Museum of Natural History.

Dimensions—Total length 31 mm, carapace 6.5 mm, rostrum 2.9 mm, telson 3.8 mm.

Description—An epipodite is present on the first, second and third legs, and on the second maxillipedes, the anterior and posteriormost being unfurcated. Somite XIII, in addition to the posterior arthrobranch, bears an unfilamentose vestige of an anterior one; the posterior margin of the gill-bearing section of the somite carries a ciliated "hairy lobule," as in various other species of this and

related genera. The basis of the first and second legs is armed with a very long and slender spine, while the ischium of the first legs bears a very small one. The longitudinal suture of the carapace is short, not reaching as far posterior as the level of the hepatic spine. The transverse suture is present.

The rostrum does not extend beyond the eye. It is not cristate over the orbit. The base is ascending; the distal portion curves downward to the horizontal. The rostrum is armed above with eight teeth in addition to the epigastric, with a rudimentary ninth tooth near the tip. The posterior rostral tooth is behind the orbital margin.

The orbital angle is produced as a large acute tooth. The postrostral carina is not strong, being only faintly indicated behind the point where the cervical sulcus would cross if continued, about at the posterior two-fifths of the carapace. The cervical sulcus is very faint dorsally, but reaches well above the level of the longitudinal suture. The cardiaco-branchial sulcus is obsolete.

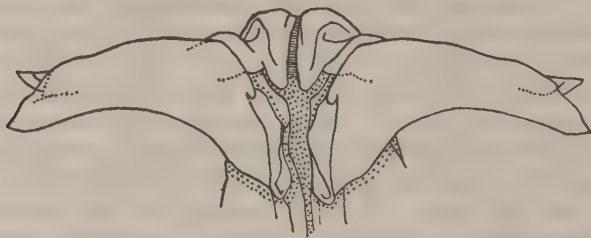


Figure 14. *Trachypeneus brevisuturæ*, n. sp.
Petasma, distal portion, distoventral view $\times 41.5$.

The fifth and sixth somites of the pleon and the posterior four-fifths of the fourth are carinated in the dorsal median line. The carina of the sixth somite only ends in a small tooth. The telson has a lateral armature of four pairs of mobile lateral spines, the penultimate pair of which is not set close to the base of the ultimate pair, but well anterior to them. The telson slopes regularly to its tip without narrowing suddenly at or behind the last pair of spines.

The carapace is naked in the branchial region; it is sparsely pubescent dorsally behind the cervical groove, heavily so before it. Patches of the carapace are naked anteroventrally, but from the ventral portion of the cervical sulcus a heavy growth of setae takes rise. The pleon is very sparsely ciliated save for a narrow dorsal band on the fifth and sixth somites.

The third walking legs extend the length of the dactyl beyond the antennal peduncle; the fourth legs to the tip of the peduncle; and the fifth legs beyond the middle of the antennal scale.

The petasma ends distolaterally in short, slender cornua the tips of which are slightly curved to ventral, and somewhat more so to proximal. The elongate

gap between the dorsal and ventral walls of the spout-like distolateral projection is in this species shifted to the dorsal margin by the increased length of the overlapping ventral wall. Near the tip of each horn on its dorsal surface is a tooth-like point directed dorsolaterally, so that in apical view of the petasma, the cornua appear bifurcate. This point locks the enlarged ventral flap down over the dorsal wall of the spout.

From the condition of the petasma and of the genital orifices I should consider this specimen to be mature, though perhaps not of maximum size for its sex. Females are no doubt much larger.

Trachypeneus brevisuturæ displays a very striking resemblance to the Indopacific species of the subgenus and section, *T. curvirostris* (Stimpson), Kishinouye 1900, De Man, 1907, Schmitt, 1926a, and to *T. asper* as described by Alcock, 1906, and *T. anchoralis* (Bate) of De Man, 1911 (not the *T. anchoralis* female of Bate, which Schmitt's description shows to be a member of the subgenus *Trachypeneus* s. s.), which are regarded by Schmitt as synonymous with *T. curvirostris*. From the Indopacific species *T. brevisuturæ* seems to be distinguished by its shorter postrostral carina; uncarinated second and third pleonic somites; more extensive dorsal cervical groove; weaker pubescence of the branchial region of the carapace and of the pleon; larger penultimate lateral spines of the telson which are placed farther anteriorad the bases of the fourth pair; more shortly triangular telson tip; shorter walking legs; quite different petasma, especially by the dorsal point of the distolateral projections; and thirteenth somite with the vestige of an anterior arthrobranch.

From an examination of two males of *T. curvirostris* (Stimpson) from Japan, kindly placed at my disposal by the Zoology Department of the Peabody Museum, it would appear that descriptions of this species require some modification. An ischial spine on the first legs, present in *T. brevisuturæ* but not in the species of the American section 1, is, although not described by Kishinouye, Alcock, or De Man, present in the specimens examined by me. A faint dorsal cervical sulcus is perceptible to some distance above the hepatic spine. The vestigial anterior arthrobranch of somite XIII, which is present in the other members of the subgenus *Trachysalambria* (no information as to the occurrence of this structure in the subgenus *Trachypeneus* s. s. being extant), appears to be absent in these two specimens, although their condition precludes absolute certainty. The anteroventral corner of the carapace is, as in other species of the genus, not strictly rectangular, the ventral margin sloping downward from the slightly produced angle before turning backward.

The crude and certainly in large part erroneous description of "*Metapenaeus*" *palaestinensis* Steinitz, 1932, evidently refers to a *Trachypeneus* (*Trachysalambria*) of section 2, and it seems probable that the organism is an Indopacific migrant through the Suez Canal. *Trachypeneus* has not been heretofore been known to have made its way into the Mediterranean. If Steinitz is correct in stating that a rudimentary anterior arthrobranch occurs on the thirteenth

somite of his material, and if this structure should prove to be constantly lacking in the Japanese *T. curvirostris*, its presence or absence might serve as a diagnostic difference between Indopacific forms of section 2, believed by Schmitt to pertain to a single species.

PARAPENEOPSIS Alcock

This genus seems to be clearly distinguishable from the second division of *Trachypeneus* (the subgenus *Trachypeneus* s. s.) only by the absence of epipodites from its third pereopods. It is a peculiar fact that, as in *Trachypeneus*, some of the species of *Parapeneopsis* possess, while some lack, the epipodites of the first and second walking legs. *Parapeneopsis balli*, new species, which constitutes the first American record of the genus, with *P. atlantica* Balss and eight Indopacific forms, two of which are represented in our material, have pereopodal epipods. Four Indopacific species, one of which is represented in our material, are without epipods behind the second maxillipede. There do not appear to be other differences correlated with the variation in branchial formula, such as in *Trachypeneus* divide the genus into two clearly distinguished groups.

If we should consider the four epipodial formulae displayed within *Parapeneopsis-Trachypeneus*, viz: (120,000)-(123,003), as characterizing homogeneous groups, it is readily evident that no scheme of descent will permit the pairing of the groups without the attribution of some of the resemblances between different groups to independent, converging development. For instance, if 123 (*Trachysalambria*) should be regarded as giving rise to 003 (*Trachypeneus* s. s.) by loss of the first and second epipods, and the latter to 000 (*Parapeneopsis*) by loss of the third; then if 120 (*Parapeneopsis*) is regarded as deriving from the other group which lacks third epipods, 000 (as is implied by the accepted generic grouping), its resemblance to 123 in possessing first and second epipods must represent a convergent reproduction of these structures. There seems to be no strong reason for believing that the presence of the third epipod indicates 003 to be more closely related to 123 than does the presence of the first and second epipods in 120.

The 123 (*Trachysalambria*) group is contrasted in structure of thelycum to the other three groups 003, 000, and 120. Since to regard the latter groups as comprising forms more closely related to one another than to 123, and as representing the three possible changes from a common ancestral formula, would remove the difficulty of choosing between the resemblances in third and in first and second epipodial formulae as a basis for postulating relationships, it is possible that a generic grouping of the species of *Parapeneopsis-Trachypeneus* primarily based upon thelycal structure might be more advantageous than the accepted one primarily based on presence or absence of the third epipod. It may be noted that in the pair of groups 120 and 000 the affinities of various species appear to cross, independently, the boundaries set up by

epipodial formula. In the lack of material of the 003 group I am unable to say whether these species display many features in common with 123 not characterizing 000 and 120, or whether they may merge with the 000-120 complex. It may be of significance that 003 and 000 are limited to the Indopacific, where 120 has its greatest development; while 123 has its greatest concentration in America. That the American *Xiphopeneus* seems rather clearly to have been derived from that section of 123 which has Indopacific representatives may perhaps afford evidence that the 123 type of thelycum with median pocket is relatively stable, so that its absence in 003 may indicate a considerable remoteness of that group from 123. The differentiation of *Xiphopeneus* also seems evidence that the center of distribution of 123, although the group includes Indopacific representatives, has for a considerable period been American as opposed to the Indopacific center common to the 003, 000, and 120 groups.

***Parapeneopsis sculptilis* (Heller)**

Parapeneopsis sculptilis, ALCOCK, 1906.

Parapeneopsis sculptilis variety *cultrirostris*, ALCOCK, 1906.

Parapeneopsis sculptilis, DE MAN, 1924.

5 males, total length 89 to 92 mm; 8 females, total length 88 to 143 mm. B.O.C. 64. Georgetown, Penang, February, 1933.

Of the five males, the three larger specimens are of the "variety" *cultrirostris*, with short, depressed rostrum armed to its distal end. The two smaller males possess a long sigmoid rostrum similar to that of females. The actual difference in size between these males is therefore more accurately expressed in terms of carapace excluding the rostrum than in total length, as follows: *cultrirostris* form, 25.5, 25, and 23.5 mm; female form, 20.5 and 21 mm.

I am unable to find any other differences between the two forms of male than those of rostrum. The depressed rostrum of the *cultrirostris* form appears to be precisely equivalent to the basal portion of the female type rostrum, and merely to lack its elongate upturned tip. It seems probable, although the material is not sufficient basis for a positive statement, that the *cultrirostris* form represents neither a variety nor, as also suggested by Alcock, a dimorphic male form, but is simply an adult instar ultimately attained by all males.

The petasma of *P. sculptilis* is of the type characteristic of the ***Trachypeneus*** series, although it is modified from the simpler petasma found in *Metapeneaus*, *Trachypeneus*, and the American and West African species of *Parapeneopsis*. The distolateral cornua, instead of being open and gutter-like, or loosely roofed over, are sealed into perfect tubes by the fusion of their dorsal and ventral walls. They open, like the fangs of a crotaline snake, only by a minute aperture at their tips. The distomedian lobe of each petasmal endopod is greatly expanded over the condition found in *Trachypeneus* and the other species of *Parapeneopsis* except *P. hardwickii*, and approaches the condition of the hypertrophied, hood-like distomedian flaps of *Metapeneaus*.

The protopodites of the male pleopods, especially the first pair, bear upon the anterolateral margins of their basal thirds a large triangular lobe in addition to the bracket at the base of the petasma.

The antennular flagella are, as described by De Man for his East Indian material, shorter than the peduncle, not longer as stated by Alcock. It may be noted here that the antennular flagella of *Parapeneopsis nana* Alcock, described (1906) as one-third of the peduncle in length, are in the figure shown as two-thirds of it.

In two of the females of the present collection three extremely minute pairs of mobile lateral spines are present on the telson, which is in the other specimens completely unarmed.

The rather remarkable coloration of formalin-preserved material three months after fixation is as follows: On an orange-red ground, (which is intense above and paler ventrolaterally and on the appendages except the posterior part of the uropods), there are arranged saddles of white in such a manner that the shrimp appears to have six broad vertical bands of color. The underlying epidermis contains red chromatophores, but the color seems to reside chiefly in the densely calcareous, almost opaque shell. Mr. Richard Colestock offers the information that the coloration was similar, but more brilliant, in fresh though not living material.

? *Parapeneopsis hardwickii* (Miers)

Figures 15 and 16, page 62.

? *Penaeus hardwickii*, MIERS, 1878.

? *Penaeus sculptilis*, HENDERSON, 1893, part.

? *Parapeneopsis sculptilis* variety *hardwickii*, ALCOCK, 1906.

1 male, 20 females. *B.O.C.* 70. Singapore, Straits Settlements, February, 1933.

4 males, total length 60 to 96 mm; 30 females, total length 85 to 115 mm. *B.O.C.* 71. Port Swettenham, Selangor, February, 1933.

1 female. *B.O.C.* 68. Georgetown, Penang, February, 1933.

In addition to this material, a female from Amoy, China in the collection of the American Museum of Natural History has been available for examination.

The rostrum is sigmoid in shape, extending at least a fourth and usually a third or more of its length beyond the antennular peduncle. The ultimate rostral tooth is placed over the second segment of the antennular peduncle, the ascending distal half or more of the rostrum being unarmed. There are seven or eight teeth in addition to the epigastric, the modal number being eight, of which the first is placed behind the orbital margin. A line connecting the tips of the teeth is hardly cristate over the orbit; the tips of the teeth are very little uptilted, and their posterior dorsal margins almost horizontal. The lateral ridge of the rostrum is usually distinct to well in advance of the ultimate tooth,

and is continued posteriorly nearly to the epigastric tooth as a distinct carina paralleling a more dorsal sulcus. In *P. sculptilis*, the rostrum is shorter; more cristate over the orbit; with distinctly uptilted teeth the modal number of which appears to be seven in addition to the epigastric; and with a shorter lateral carina.

The postrostral carina continues nearly to the posterior margin of the carapace. It is sulcate, the sulcus being more broadly open and less constricted between its postepigastric and its cervical expansions than is the case in *P. sculptilis*. The sulci which in *P. sculptilis* run along above and below the cardiaco-branchial ridge are in *P. hardwickii* nearly obsolete, and the ridge is therefore inconspicuous in the latter species. The longitudinal suture usually extends behind, but sometimes ends anterior to the transverse suture. The anteroventral angle of the carapace is somewhat produced but hardly dentiform; the anterior portion of the cervical sulcus ends well behind the margin. The carapace is somewhat tomentose in its anterodorsal region, while the remainder of the carapace and the pleon are finely granulate.

The sulcate crest present on the first to third pleonic terga of *P. sculptilis* is absent from these somites in *P. hardwickii*, although the third is somewhat compressed in its posterior part. The fourth, fifth and sixth somites are sharply carinate, but the small spine in which these segments end in *P. sculptilis* occurs in the present species only on the sixth. The telson bears from three to five, usually four, pairs of mobile lateral spines. These spines, although not conspicuous, are much larger than those occasionally present in *P. sculptilis*. The apical pair is the largest; the penultimate and antepenultimate pairs smaller and subequal; the anteriormost pair, set considerably proximad the others, smallest.

The antennular flagella are somewhat longer than their peduncle. The antennal peduncle is slender, and never extends as far as to the end of the eye; whereas in *P. sculptilis* the structure is stouter and extends well beyond the eye.

The basis of the first and second legs is armed with spines considerably longer and slenderer than are those of *P. sculptilis*. The ischium of the first legs and the basis of the third are, as in the related form, unarmed. The uropods extend about one-sixth of the telson length beyond the telson and are thus comparatively longer than are those of *P. sculptilis*.

The petasma is much like that of *P. sculptilis*, but the distomedian lobes, instead of extending wing-like in a distolateral direction beyond the lateral cornua, are considerable smaller and shorter. The lateral margins of the petasma rise straight to the cornua instead of being considerably constricted just below them as in *P. sculptilis*; the cornua are elongate and their tips are directed laterally, not twisted to point lateroventrally. There is a clump of setae on the sternum of the male of *P. hardwickii* just behind the coxal projection of the fifth leg which is absent in *P. sculptilis*.

The lateral hoods of the thelycum of this, as of most other species of *Para-*

peneopsis, are very considerably reduced. The transverse groove is represented only by two very short lateral sections enclosed between the lateral hoods and the median plate. The minute pair of sperm receptacles here formed have ventral entrances by notches bounded anteriorly and medially by the median plate; and posteriorly and laterally by the lateral hoods. The exit from each cavity is a narrow gap between the dorsolateral margin of the median plate and the anteromedian margin of the lateral hood, which embraces the median plate. The chief difference between the thelycum of *P. hardwickii* and that of

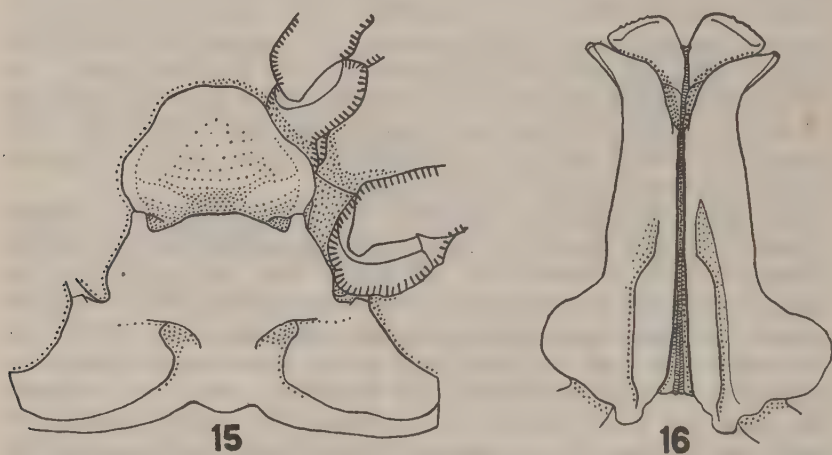


Figure 15. *Parapeneopsis hardwickii* (Miers). Thelycum, $\times 8$. Figure 16. *Parapeneopsis hardwickii* (Miers). Petasma, ventral view $\times 8$.

P. sculptilis lies in the much less extensive entrance notches of the former species, the bridge between the median plate of XIII and the sternite posterior to it being along a surface over half as broad as the median plate itself, while in *P. sculptilis* the notches (the median ends of either half of the transverse groove) extend far in toward the median line and the union between the median plate and posterior sternal surface occurs across a much narrower neck. There is a further conspicuous difference between the two species in the shape of the lateral margin of the lateral hoods of XIV, which are in *P. sculptilis* much more deeply indented behind their point of contact with the median plate.

The sperm cavities are astoundingly minute, having capacities of much less than a cubic millimeter in mature females. The small quantity of sperm, relative to other peneids, which can be stored in these receptacles, must therefore be utilized in *Parapeneopsis* with a very great relative efficiency; or the quantity of eggs to be fertilized by a single impregnation must be small. The

extremely specialized injection apparatus of the male is evidently correlated with the minuteness of the female receptacles. Dissection of the male reveals that, as in *Trachypeneus* and *Xiphopeneus*, but not in *Metapenaeus*, *Penaeus*, *Parapenaeus*, *Penaeopsis* and *Eusicyonia*, the sperm are packed in numerous minute ellipsoidal membraneous sacs. In the present species there are not more than thirty or forty spermatozoa in each of the minute spermatophores, loosely packed without orderly arrangement. The spermatophores in the lower end of the vas deferens are mixed with a rather abundant matrix of minute refracting granules; in the cavities of the thelycum following transfer, the walls of the spermatophore seem to disintegrate, and the sperm to lie embedded in the compacted matrix. The sperm are elongate, with a tapering, cylindrical refracting appendage at one end and a refracting disc at the other. They thus resemble the spermatozoa of *Xiphopeneus*.

In impregnated females the entrance notches are filled with a gummy yellowish material which is copiously spread over the adjacent hollows of the median plate. In some species of *Parapeneopsis* (notably in *P. atlantica* Balss, where the margins of sternites XIV and XIII are raised chalice-like to hold the mass) the sperm-free male secretion smeared over the surface of the thelycum becomes enormous in quantity. The thelycum of *Parapeneopsis* seems to derive from a less simplified form such as is found in the first subgenus of *Trachypeneus*, in which this secretion is stored in a special median cavity of the transverse groove and may be necessary to seal the relatively very wide entrances to the sperm receptacle. The mass in *Parapeneopsis*, aside from the small quantity which actually seals the narrow entrances to the cavities, appears functionless.

The coloration of *P. hardwickii* is quite different from that of specimens of *P. sculptilis* preserved under the same conditions. The entire animal is suffused with pale pinkish-orange, stronger at certain points than at others, but in no way gathered into bands. There is a sprinkling of blue chromatophores on the pleon, posterior and anterior margins of the carapace, and especially on the rostrum; such blue pigment is almost lacking in *P. sculptilis*. The postrostral carina is a vivid orange-brown, a tint not found in the corresponding region of *P. sculptilis*.

The specimens described above under the name ? *P. hardwickii* are certainly distinct from *P. sculptilis*, and are quite different from any other known species of *Parapeneopsis* except the form described by Miers. There are some differences between Miers' description and the above, and it was at first intended to accept Alcock's statement that *Penaeus hardwickii* Miers is merely a variety of *P. sculptilis*, describing the present material as a distinct species under the name *Parapeneopsis colestockii*. However, the discrepancies, to be mentioned below, do not seem sufficient to warrant such procedure.

Both Miers and Alcock mention the telson of *P. hardwickii* as unarmed, a statement not applying to the present species, and especially curious in view of the fact that Alcock had apparently discovered the rare and much more

minute lateral spines of *P. sculptilis*. Miers' description of *P. hardwickii* is perfectly applicable to the present species in other characters, except that the antennular flagella are figured as shorter than the peduncle, a distinguishing characteristic of *P. sculptilis*. Alcock, in controversion of his text, figures the antennular flagella of his *P. sculptilis* as shorter than the peduncle; and in consideration of his statement as to telson armature it seems possible that the text may in part have been derived from specimens of the present species. I am unable to discover any similarity in the female genital sternites of the present specimens, as contrasted with *P. sculptilis*, to Alcock's description of the thelycum of *P. hardwickii* as like a "vertical section of a mushroom." Henderson, 1893, seems to have confused the present species with the true *P. sculptilis*, and other records of the latter may be doubtful in part or whole.

From the related *Parapeneopsis uncta* Alcock the present species appears clearly distinguished by the lack in the former of a spine on the basis of its second chelipeds and of a lateral telson armature; the absence in ventral view of distomedian lobes from its petasma; its shorter antennular flagella and longer uropods; its shorter rostrum; its more strongly defined cardiaco-branchial sulcus, and its less tomentose carapace.

***Parapeneopsis balli*,¹ new species**

Figure 17, page 65.

Two males, the type and cotype, were taken at Acajutla, El Salvador, in April, 1866, by Mr. F. H. Bradley. The type is contained in the collection of the Zoology Department of the Peabody Museum of Natural History; while the cotype has been deposited in the American Museum of Natural History.

Dimensions—Type, total length about 37 mm, carapace 7.8 mm, rostrum 3.8 mm, telson 4.4 mm (tip broken). Cotype, total length about 21.7 mm, carapace 4.8 mm, rostrum 1.9 mm, telson 3 mm.

Description—An epipodite is present on the first and second legs and on the second maxillipedes. Somite XIII lacks any vestige of an anterior arthrobranch; a ciliated "hairy lobule" is present on the posterior margin of the somite. Longitudinal and transverse sutures are present, the former extending somewhat behind the middle of the carapace, but not to the level of the transverse suture.

The rostrum of the type reaches to the basal one-fifth of the second segment of the antennular peduncle. It is directed upward at the base, the upper margin rising into a crest highest just beyond the orbital margin. The tip is horizontal. The blade narrows considerably distal to the third tooth. The armature consists of six teeth in addition to the epigastric, of which the most proximal is behind the orbital margin. The ultimate tooth is as far from the tip as from the penultimate tooth, and one and one-half times as far from the latter as the latter from the antepenultimate.

¹ Named for Dr. Stanley Crittenden Ball.

The orbital angle is small but dentiform; the anteroinferior angle of the carapace rounded. The postrostral carina extends as an obtuse but not sulcate ridge to the posterior one-fourth of the carapace. The dorsal cervical sulcus reaches about as far dorsad as the longitudinal suture; it ascends very obliquely, roughly paralleling the anterior part of the cardiaco-branchial ridge. The anterior cervical sulcus (which is continued behind the hepatic spine as the cardiaco-branchial sulcus) does not reach nearly to the anterior margin of the carapace. It is not sigmoid, and is directed forward rather than ventrad.

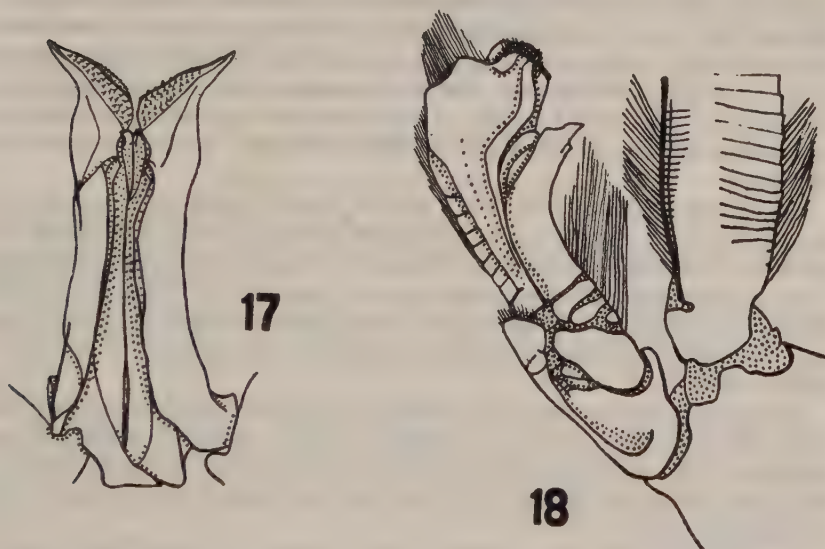


Figure 17. *Parapeneopsis balli*, n. sp.
Petasma, ventral view $\times 18.2$.

Figure 18. *Parapeneopsis hungerfordi* Alcock.
Second pleopod of male, showing appendix masculina and modified endopod,
posterolateral view $\times 12$.

The third pleonic somite bears a blunt trace of a middorsal crest on its posterior part; the fourth, fifth and sixth somites are carinate, the carina of the fifth and sixth being sulcate, and ending posteriorly in a blunt tooth. The extreme tip of the telson is broken; to this point no trace of a lateral armature is perceptible.

The entire carapace is punctate-pubescent, although very weakly so in the branchial region; the pubescence is especially strong in the anteroventral area.

The third walking legs reach to the basal half of the antennal peduncle; the fourth fall short of this point; the fifth fall somewhat short of the end of the antennal scale. All the legs are completely unarmed. The outer antennular

flagella are about one-fourth shorter than the inner; the inner are about one-fifth their length longer than the antennular peduncle and the same amount shorter than the carapace.

The petasma possesses very small basolateral wing-like lobules. The lateral cornua are short and are directed laterodistally, somewhat as in the figure of *P. uncta* Alcock, 1906. The distomedian lobes, however, are directed ventrally somewhat like those of *P. atlantica* Balss, 1925, being neither greatly expanded and lapping the lateral cornua as in the Indopacific *P. sculptilis* (Heller) and *P. hardwickii* (Miers) nor absent as in the figures of *P. stylifera* (H. Milne Edwards) Alcock, 1906, *P. cornuta* (Kishinouye), 1900, *P. marillipedo* Alcock, *P. gracillima* Nobili (De Man, 1924), and *P. nana* Alcock, nor directed dorsally as they appear in the figure of *P. uncta* Alcock. The distal margins of the cornua are scabrous and spinose. The ventral margins of these spout-like projections overlap the dorsal ones, the channels being thus loosely roofed over. The type appears to be mature.

The immature cotype male has a shorter rostrum which does not extend beyond the basal segment of the antennular peduncle, and is less cristate in advance of the orbital margin than in the type. There are five teeth in addition to the epigastric, and a further rudimentary one near the tip. The telson bears three pairs of very minute and closely crowded mobile lateral spines near the tip. Behind the ultimate spines the telson narrows very sharply to a short and slender point.

The outer antennular flagella of the cotype are little more than one-half the inner; the inner are as long as the peduncle, about two-thirds as long as the carapace. The third legs extend beyond the middle of the antennal peduncle, the fourth pair beyond the peduncle, while the fifth fall well short of the end of the antennal scale.

Parapeneopsis balli shows no striking relationship to any Indopacific species. It is quite distinct from the Eastern Atlantic *P. atlantica* Balss, especially in its more sparingly toothed and not styliform rostrum; definite postrostral carina; anterior cervical sulcus not sigmoid and directed anteriorad rather than ventrad; more minute and distally concentrated telson spinules; walking legs unarmed at base; and very different petasma which, however, in the structure of its distomedian lobes and in the fact that the anterior and posterior walls of the lateral cornua are not soldered together to form a perfect tube, seems nearer to that of *P. atlantica* than to the Indopacific species as far as these are known to me.

It may be noted that the longitudinal suture of *P. atlantica* does not extend nearly to the posterior margin of the carapace as figured and described by Balss, 1925, and stated for the male by Schmitt, 1926b, in any of the material in the collection of the American Museum of Natural History; in which the fissure reaches no farther than to somewhat behind the middle of the carapace. It may also be noted that Balss, although declared by Schmitt to describe

basal spines as present on the first legs only, correctly mentions them as "auf den ersten beiden pereipodenpaaren."

Parapeneopsis balli is distinguishable from all the species in which epipodites are present on the first two walking legs except *P. gracillima* Nobili by its complete lack of basal armature on the chelipeds, as well as by other characters. It is readily separated from *P. gracillima* by the fact that the latter lacks an epigastric tooth, has longer antennular flagella, and has longer, slenderer lateral cornua of the petasma, which appears to lack distomedian lobes.

It seems possible that *Penaeus pubescens* Stimpson is the Atlantic American congener of *Parapeneopsis balli*. If Stimpson's description is correct the two forms appear to be distinct in many features. *Parapeneopsis balli* is the first recognized member of the genus to be taken in American waters.

***Parapeneopsis hungerfordi* Alcock**

Figures 18, page 65; 19 and 20, page 69.

Parapeneopsis hungerfordi, ALCOCK, 1905.

4 males, maximum total length, 120 mm. *B.O.C.* 65. Singapore, Straits Settlements, February, 1933.

3 males, maximum total length 88 mm; 10 females, maximum total length 120 mm. *B.O.C.* 67. Port Swettenham, Selangor, February, 1933.

3 males, total lengths 65 to 77 mm; 14 females, total lengths 74 to 94 mm. *B.O.C.* 66. Georgetown, Penang, February, 1933.

The present material, taken far from the type locality, agrees fairly well with Alcock's brief and rather general diagnosis of three specimens, the only heretofore known, from Hong Kong. It is a remarkable circumstance that abundant material of this and of *P. hardwickii*, neither reported since Alcock, 1906, should have been obtained remote from previous records in the commercial catch of a relatively well known area.

Parapeneopsis hungerfordi, unlike the three species of the genus described above, lacks epipodites behind the second maxillipedes, and with *P. tenellus* (Ortmann), *P. acclivirostris* Alcock, and *P. venusta* De Man, has been mentioned in a preceding paragraph as the 000 group.

The female rostrum is shorter than in *P. sculptilis*, extending very little, not over one-eighth of its length, beyond the antennular peduncle. Its basal, armed portion is less depressed than in *P. sculptilis*; the distal portion, which is unarmed for no more than one-third, usually one-fourth, of the rostral length, is slightly ascending beyond the penultimate tooth. There is a small but conspicuous epigastric tooth. The rostral teeth are well spaced; the distalmost not much separated from the penultimate. The tips of the teeth, particularly the posterior ones, are not much uptilted. The rostrum is hardly cristate over the orbital margin. The number of teeth varies from six to eight in addition to the epigastric, the modal number being seven. The rostrum of the male is

slightly shorter than that of the female, but not as short as in Alcock's specimen in any of my material; the distal portion is somewhat less upcurved than in the female.

The postrostral carina, which reaches almost to the posterior margin, is sulcate, but the sulcus is not strongly constricted in its midsection. The antero-inferior angle of the carapace is almost as acute as that of *P. sculptilis*. The anterior portion of the cervical sulcus does not reach the margin. The cardiobranchial sulcus is fairly well marked; the sulcus ventral to the cardiobranchial carina almost obsolete. The longitudinal fissure extends to somewhat behind the level of the transverse.

There is a faint longitudinal depression in the dorsal midline of the anterior part of the first pleonic somite, a very faint compression of the posterior part of the second, and a slight compression of the third; the fourth, fifth and sixth are sharply carinate, but only the sixth ends posteriorly in a spine. The telson is completely unarmed. The surface of carapace and pleon is punctate.

The antennular flagella are hardly more than one-half the length of the peduncle in the female, slightly longer in the male. The antennal peduncle is much shorter than in *P. sculptilis*, not reaching the middle of the eye. There are strong elongate basal spines on the first and second legs. The first pleopod of the female has a minute endopod, which is larger than the barely discernible rudiment found in *P. sculptilis* or in *P. atlantica* Balss.

The petasma is of a striking and peculiar form. The distomedian lobes, as in all species of *Parapeneopsis* except *P. sculptilis* and *P. hardwickii*, are greatly reduced, and form a pair of hardly perceptible lobules on either side of the point where the cincinnulate median margins of the endopods terminate. The distolateral lobes, instead of being the usual laterally directed hornlike appendages, are semirectangular and are directed straight distad, their median margins nearly in contact. They are greatly enlarged, being nearly three quarters as long as the body of the petasma. At the laterodistal corners of these highly modified cornua there is a fleshy tooth directed mediodistad. Dorsad and mediad this tooth is a fleshy lobule. The lateral bracket-like projections at the proximal ends of the petasmal endopods have, as in Alcock's words, "the free edge deeply notched."

The first pleopods of the male lack the basal anterolateral projections found in *P. sculptilis* and *P. hardwickii*. The appendix masculina of the male second pleopods is quite similar to this structure in *P. sculptilis*, but the endopod has been converted into a stiff, ridged, spatulate blade, its flagelliform character being completely lost.

The thelycum is modified from the form typical of *Parapeneopsis* by the almost complete obliteration of the usually extensive sternal area behind the juncture of the median plate and the lateral hoods. This obliteration has been accomplished by the displacement of the median ends of the transverse groove to a posterior position. The median plate, which is longitudinally depressed

in the midline, thus extends far back, almost to the level of the posterior margins of the fifth legs. Between the fifth legs it is greatly expanded, having the form of a low plate extending so far laterad as to almost cover the narrow sternal ridges which form the posterior parts of the lateral hoods. The anterior expanded parts of the lateral hoods extend forward from beneath the outer anterior margins of the expanded parts of the median plate. The exits of the minute sperm-receptacle cavities are on the inner margins of the anterior parts of the lateral hoods, in the gap between these and the narrower anterior part

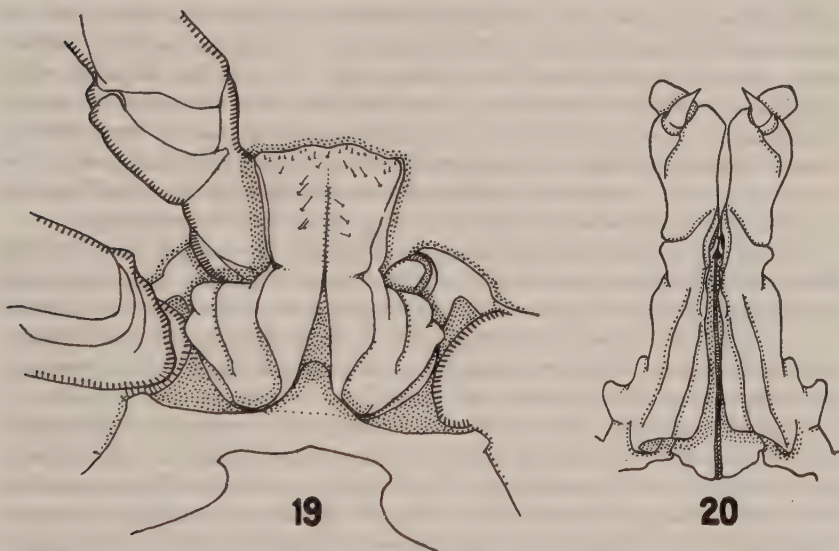


Figure 19. *Parapeneopsis hungerfordi* Alcock. Thelycum $\times 8$. Figure 20. *Parapeneopsis hungerfordi* Alcock. Petasma, ventral view $\times 8$.

of the median plate. The entrances appear to lie just behind the median plate on either side of its triangular depressed part. The receptacles are thus very much elongated, but their lumens are extraordinarily narrow posteriorly, expanding beneath the broadened anterior parts of the lateral hoods. The appearance of the thelycum is somewhat variable with individual, and considerably so with size. In the younger females, by contrast with the large figured specimen, the thelycum has a median plate with more sloping and un-sinuuous anterior margin; shorter, broader median depression, and less distinctly delimited lateral expansions.

The elongate spermatozoa, somewhat like those of *P. hardwickii*, are in the vas deferens of the male found enclosed, from one to two hundred per packet,

in minute, resistant, bean-shaped sacs. The posterior pointed ends of the sperm cells are all directed toward a point which would correspond to the hilum of a bean. Mixed with the spermatophores are long, curved, doubly clavate rods of a clear refracting substance, which evidently correspond to the minute refracting granules in *P. hardwickii*.

In formalin preserved material there is a conspicuous transverse band of orange coloration on the posterior part of the tergum of each pleonic somite.

P. hungerfordi is readily distinguished from other species which lack epipodites on the first and second legs, as follows: From *P. tenellus* and *P. acclivirostris* by the absence in these of an epigastric tooth and a postrostral carina, and the occurrence in them of a more typical thelycum. The petasma of *P. tenellus* seems to be of a quite usual form characteristic of a number of species with epipods on the first and second legs, *P. stylifera* (H. Milne Edwards), *P. cornuta* (Kishinouye), *P. maxillipedo* Alcock, *P. gracillima* Nobili, and *P. nana* Alcock. From *P. venusta* De Man, *P. hungerfordi* is distinguished by the absence in the former species of a postrostral carina and a basal spine on the second leg, the presence of a lateral telson armature, and of a thelycum of normal type.

A considerable number of the characters described above, especially the lack of any clear carination on the anterior three pleonic terga and the conspicuous modification of the endopod of the second pleopods of the male are difficult to reconcile with Alcock's statement that in other respects than its different branchial formula, the more rectangular anteroinferior angles of its carapace, its shorter antennular flagella and its different thelycum and petasma, *P. hungerfordi* resembles *P. sculptilis*. Alcock's brief description of thelycum and petasma are with some manipulation of the terms applicable to the present form, but it is within possibility that they apply to a related but distinct species. Therefore, although the probability that the specimens described above are identical with the Chinese material examined by Alcock is sufficiently strong so that they have been attributed to *P. hungerfordi*, attention may be called to their possible distinctness.

EUSICYONINAE Burkenroad, 1934

EUSICYONIA Stebbing

Prior to the present studies about twenty-two or -three species and varieties of *Eusicyonia* were known, thirteen from the Indopacific, one from the Eastern Atlantic and Mediterranean, five from the American Atlantic, and three from the American Pacific. In the preceding paper (Burkenroad, 1934), the distinctness of the stillborn American Atlantic *E. stimpsoni* (Bouvier) from *E. dorsalis* (Kingsley) has been demonstrated. The present paper adds another undescribed species, *E. parri*, to the fauna of the American Atlantic, and removes one previously accepted form, *E. carinata americana* (De Man), to the synonymy of *E. laevigata* (Stimpson). Six species are added to the American

Pacific fauna, of which two are identical with Atlantic species, while four are new.

The Eusicyoninae are an extremely uniform monogeneric assemblage. No means of subdividing the genus has heretofore been suggested, and it is perhaps for this reason as well as because full advantage has not been taken of the excellent specific characters available, that some confusion of the species has existed.

The genus *Eusicyonia* is divisible into two superspecific groups, which center about *E. carinata* (Olivi) and *E. edwardsi* (Miers) respectively, as follows:

DIVISION I. Antennal angle unarmed. Dorsal carina of the second pleonic somite notched dorsad the junction of the transverse sulci. Dorsal carina of the fifth pleonic somite not ending posteriorly in a tooth or sharp angle. Basis and ischium of the first chelipeds armed with a spine. Species examined: *E. laevigata* (Stimpson), Atlantic and Pacific America; *E. parri*, n. sp., Atlantic America; *E. disparri*, n. sp., Pacific America; *E. carinata* (Olivi), Mediterranean and Eastern Atlantic; *E. ocellata* (Stimpson), Indopacific.

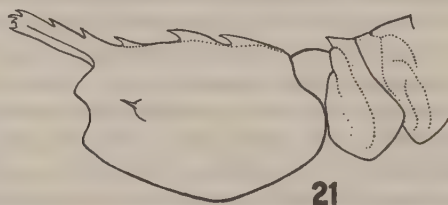
In the above species of Division I, which may be termed the **carinata** group, there are only two or, barely, three carapacic teeth behind the level of the hepatic spine; the posteromedian sulcus of the second and third pleonic somites turns anteriorly at its dorsal end and is margined above by a longitudinal ridge; and the petasma displays a deep notch in its lateral margins.

It appears that all or almost all of the known Indopacific species of the genus are also to be considered as members of Division I, although available descriptions and figures are to a considerable extent insufficient for final determination of this point. *E. rectirostris* (De Man), *E. parvula* (De Haan), *E. ocellata* (Stimpson), *E. laevis* (Bate), *E. curvirostris* (Balss), and *E. bispinosa* (De Haan) appear to be more or less typical members of the **carinata** group. Records of *E. carinata* (Olivi) from the Indopacific in all probability refer to related but not identical species.

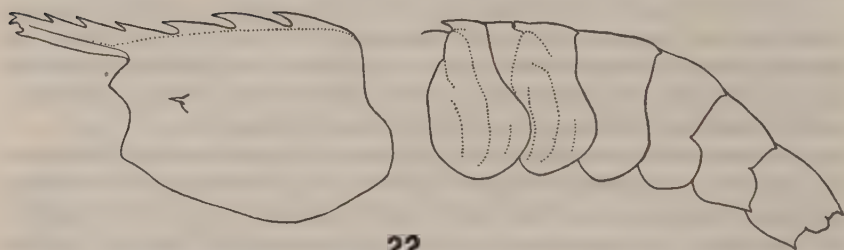
On the other hand, *E. cristata* (De Haan), *E. furcata* (Miers), *E. japonicus* (Balss), and *E. lancifer* (Olivier), although they appear to pertain to the Division in diagnostic characters, diverge from its more typical members by the occurrence of three or more postrostral teeth behind the level of the hepatic spine. *E. furcata* seems somewhat to resemble *E. ocellata*, and like it has longitudinal ridges paralleling the anteriorly turned dorsal ends of the posteromedian pleural sulci. It may be noted that in specimens of *E. ocellata* available to me, the petasma lacks clearly cut lateral notches. *E. cristata*, *E. japonicus*, and *E. lancifer* seem to be nearly related forms and to lack, as far as information is available, the longitudinal pleonic ridge and petasmas notch.

The longitudinal pleonic pleural ridge does not occur in all members of the first Division, and very slight indications of a similar ridge are borne by *E. affinis* (Faxon) and *E. aliaffinis*, n. sp., of the second Division. The petasmas notches seem to occur only in Division I, although they are not there of universal

occurrence. The various numbers of postrostral teeth occurring behind the hepatic spine in the first Division are in part overlapped by tooth ratios occurring in the second, but it may be of some significance that no members of Division II with three or more teeth constantly behind the level of the hepatic spine are known, whereas conversely, no known members of Division I [with the possible exception of *E. benthophila* (De Man), the affinities of which are doubtful] have fewer than two teeth behind the level of the hepatic spine. Of the char-



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Figure 21. *Eusicyonia laevigata* (Stimpson).

Carapace and anterior portion of pleon of Puerto Rican female, lateral view $\times 4.4$.

Figure 22. *Eusicyonia parri*, n. sp.

Carapace and pleon, lateral view $\times 4.4$.

acters given rank as diagnostic of the first Division as a whole, a very broad, shallow and inconspicuous emargination of the second pleonic carina occurs in *E. affinis*, *E. aliaffinis* and *E. edwardsi* (Miers) of the second Division. In *E. trispinosa* (De Man), a species certainly very closely related to *E. carinata* in other characters (although with three postrostral teeth behind the hepatic spine), and even displaying the petasmas notch, there seems to be no incision in the dorsal carina of the second pleonic somite; the same may be remarked of *E. fallax* (De Man). *E. benthophila* (De Man) bears a considerable resemblance to *E. affinis* (Faxon) [rather than, as De Man has it, to *E. picta* (Faxon)], and indeed might be a typical member of that group were its first chelipeds not reported to be armed on basis and ischium. The lack of a true, buttressed, tooth at the acute antennal angle of *E. benthophila*, another carinata-like

character, may be merely an attribute of immaturity, since the buttress is ill-marked in juveniles of the second Division.

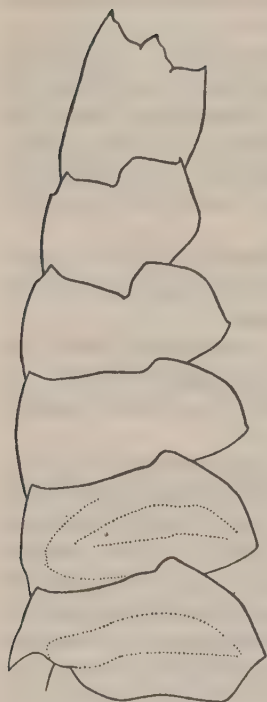
DIVISION II. Antennal angle armed with a buttressed spine. Dorsal carina of the second pleonic somite not incised. Dorsal carina of the fifth pleonic somite ending posteriorly in a tooth or sharp angle. Basis and ischium of the first chelipeds unarmed. Lateral margins of the petasma not sharply notched. Posteromedian pleural sulci not contributing dorsally to the formation of a conspicuous longitudinal marking. Species chiefly or completely limited to America.

1. **brevirostris** group. Postrostral carina with three or four teeth behind the orbital margin, of which three are large and placed far behind the orbit. *P. brevisrostris*, (Stimpson), Atlantic and Pacific America.

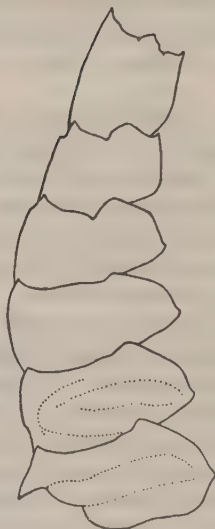
2. **edwardsi** group. Postrostral carina with two or three teeth behind the orbital margin, of which two are large and placed far behind the orbit. *E. edwardsi* (Miers), Atlantic America; *E. disedwardsi*, n. sp., Pacific America; *E. penicillata* (Lockington), Pacific America.

3. **affinis** group. Postrostral carina with two teeth behind the orbital margin, of which one is large and placed behind the level of the hepatic spine. *E. affinis* (Faxon), Pacific America; *E. aliaffinis*, n. sp., Pacific America; *E. stimpsoni* (Bouvier), Atlantic America; *E. picta* (Faxon), Pacific America; *E. dorsalis* (Kingsley), Atlantic America; *E. disdorsalis*, n. sp., Pacific America. As has been previously mentioned, the Indopacific *E. benthophila* closely resembles *E. affinis*, so far as information is available, and may in its divergencies actually represent a point of intergradation of the first and second Divisions.

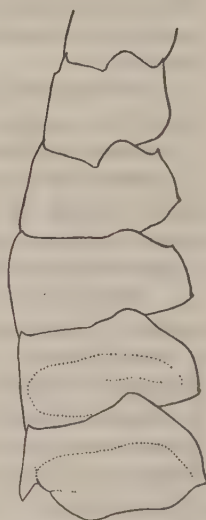
An account of the morphology and development of Eusicyoninae bearing on their relationship to other Penaeidae, with a considerable revision of the views previously current, has been given in the preceding paper (Burkenroad, 1934). The characteristics of the subfamily which are important in the evaluation of its species may be discussed as follows: The range of adult size within a species of the genus is much greater than in other Penaeidae. Sexual maturity may be attained at a size so much less than the maximum, and immature individuals are relatively so rare that a rapid maturation and a very extended adult life seem implied. I have observed impregnated females of *E. disdorsalis* over the enormous range in carapace length of 6.1 to 17.6 mm, and males with united copulatory endopods from 5.5 to 13 mm. Differences between small and large individuals of any species are slight and chiefly affect the rostral length, elevation, and distal armature, these features in general becoming respectively shorter, more horizontal, and with more numerous distal teeth as size increases; and the armature of the pleonic pleura, which generally increases in strength and extent with growth. The male and female genital sternites often change slightly with increasing size; and the relative positions of the postrostral teeth of the carapace may change to a very small extent. The petasma, after union of its halves, and the pleonic sculpture, seem to be astonishingly constant.



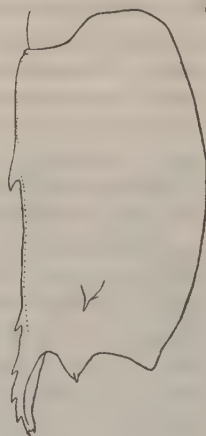
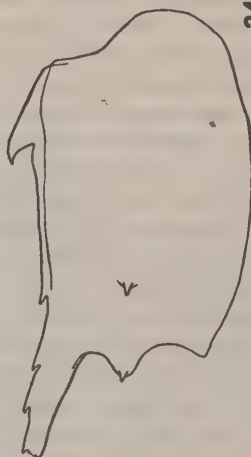
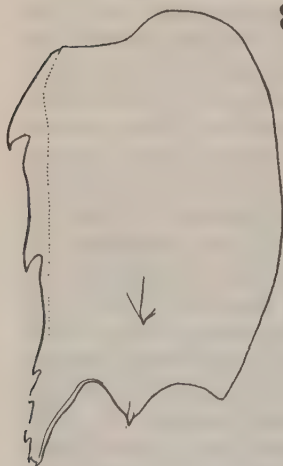
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The range of interspecific variation within the genus in any set of structures—as for example, in the number of postrostral teeth—is not very great, but the various possible recombinations of the different sets of characters are sufficient to provide quite clearcut diagnostic distinctions between a considerable number of species. It is very probable that future studies will provide species to fill certain unoccupied niches left by possible recombinations within the known range of variation of the genus.

The postrostral armature, as well as the rostrum, is subject to some individual, intraspecific, variation, and although providing characters of great value in separating superspecific groups, is not as serviceable for specific differentiation unless the range of variation can be fixed.

The thelycum and the corresponding male genital sternites, less varied than among other penaeid groups, sometimes supply diagnostic features; the thelycum chiefly by the outline of the posterior margin of the thirteenth sternite, which forms the anterior lip of the transverse groove; the male genital area chiefly by the shape of the transverse elevation lying just anterior to the suture between the thirteenth and fourteenth sternites. The length and outline of the large spine of the thirteenth sternite are too insusceptible of exact description and with too limited a range of variation over the genus and too high a rate of individual variability, to be of very considerable service.

The pleonic pleural armature of *Eusicyonia* is subject to considerable intraspecific variation, chiefly with age, but when the range of this variation or its size-correlation can be determined, is taxonomically useful. The armature always consists of a posteriorly directed tooth or acute angle at the posterior ventral margin of the pleura of the sixth pleonic somite; this may be increased by the addition of POSTERIOR VENTRAL spines or angles on somites anterior to the sixth. The increase always occurs from behind forward both ontogenetically and between species, so that the segments posterior to any which bear a posterior ventral spine will be armed. The armature of the pleon may be further increased by the appearance of spines or angles on the anterior surfaces of the pleural ventral margins, these ANTERIOR VENTRAL spines chiefly occurring on the somites anterior to those bearing posterior ventral spines, although the two series often overlap in the middle of the pleon. An additional armature may appear posterodorsal to the posterior ventral spines. The pleural armature is increased in direct correlation with increase in size of the individual. A rounded angle usually precedes an unarmed but acute angle, and this a veritable tooth, in the course of individual development.

Figure 23. *Eusicyonia disedwardsi*, n. sp.
Carapace and pleon, lateral view $\times 3.7$.

Figure 24. *Eusicyonia altiaffinis*, n. sp.
Carapace and pleon, lateral view $\times 3.7$.

Figure 25. *Eusicyonia disdorsalis*, n. sp.
Carapace and pleon, lateral view $\times 3.7$.

The transverse sulci of the pleon, which have not heretofore been employed with any precision, provide extremely constant and valuable specific characters. The most complete series of these grooves would be composed of six sulci on either side of each somite, as follows: From a dorsal midpoint on each dorso-lateral surface, two grooves, the ANTERIOR and the POSTERIOR TERGAL SULCI, extend ventrad for a variable distance, sometimes to the ventral margin. From a ventral midpoint two grooves, the ANTEROMEDIAN and POSTEROMEDIAN PLEURAL SULCI, run dorsad within the area enclosed by the tergal sulci. From a still more ventral midpoint two grooves, the ANTERIOR and the POSTERIOR PLEURAL SULCI, run dorsad outside the area enclosed by the tergal sulci. The sulci vary in occurrence, depth, length, and direction from somite to somite in a single individual, as well as between equivalent somites in different species. They appear to be practically invariable with growth or otherwise, within the species. Anastomoses between tergal and pleural sulci may occur, and it is often difficult to be certain of the precise homologies of the various grooves according to the foregoing scheme. The sulci are present in a form most nearly like ideal series given above on the second and third somites. On the lateral surfaces of the sixth pleonic somite there is a longitudinal sulcus flanked above and below by ridges.

DIVISION I

***Eusicyonia laevigata* (Stimpson)**

Figures 21, page 72; 26, page 82; and 32, page 91.

Sicyonia laevigata, STIMPSON, 1871; RATHBUN, 1901, part; HAY and SHORE, 1918.

Sicyonia carinata americana DE MAN, 1907.

Material examined includes a female of carapace length 4.9 mm, total length 20 mm, a female of carapace 4.7 and total length 18 mm, and two males, one damaged, the other of carapace 3.3, total length 14 mm, collected on the Pacific coast of Panama in 1866 by Mr. F. H. Bradley, and contained in the collection of the Zoology Department of the Peabody Museum of Natural History. Of Atlantic material for comparison, 2 males and 9 females from the collections of the Zoology Department of the Peabody Museum and of the American Museum of Natural History were available. This material was collected in Puerto Rico, the Bahamas, and North Carolina; it ranges in carapace length from 2.6 to 12.1 mm, the two males being respectively 2.9 and 4 mm.

There are no perceptible diagnostic differences between the Atlantic and the Pacific specimens, although the rostrum of Pacific specimens is somewhat shorter than that of Atlantic specimens of similar size. There are no previous Pacific American records of any species of the Division.

The Pacific specimens may be described as follows: Dorsal carina of the carapace with three teeth behind the orbital margin, of which two are behind

the level of the hepatic spine. The posterior tooth in the three undamaged specimens is respectively 28, 30 and 31% of the carapace length anterior to the posterior margin of the carapace. The penultimate tooth is 58% anterior to the posterior margin. The anterior tooth is 11 to 12% behind the orbital margin and 8 to 12% anterior to the hepatic spine. The distance between the anterior and the middle tooth is in all three specimens greater than that between the middle and the posterior tooth, although almost imperceptibly so in the two larger individuals. All measurements in this and succeeding paragraphs have been made with micrometer ocular at a magnification of not less than 9 diameters.

The postrostral teeth are directed anteriorly at an angle of less than 45° to the dorsal margin of the carapace. In advance of each tooth, the low carina which forms the crest of the preceding tooth is practically obliterated. The middle tooth is the largest; the anterior tooth is much smaller than the two posterior to it, about equal in size to the rostrals, and appearing as a part of that series.

The rostrum is fairly elongate, from 46 to 51% of the carapace in length, its average being 48.6%. It is quite narrow, the depth just anterior to the basal tooth being 11 to 13, mean 12%. The superior and inferior margins are subparallel; that is, there is little taper from base to tip. The length of the rostrum makes conspicuous its elevation of about 20° . It bears two teeth behind the terminal portion, of which the posteriormost is in the smaller specimen 10, in the two larger, 13% anterior to the orbital margin. The second tooth is placed somewhat distad the middle of the rostrum. The third tooth, which might be regarded as occurring on the dorsal margin of the rostrum, is placed about as far from the second tooth as is this from the posterior tooth. Its anterior margin is 6 to 8% of the carapace length behind the tip of the fourth tooth, and slightly behind the posterodorsal margin of the sixth, ventralmost tooth. The terminal portion of the rostrum in these specimens appears divided into four teeth, the two middle elements projecting farthest and being separated from each other by a shallower notch than they are from the tooth ventral, and particularly, that dorsal to them. Just above the ventral margin of the rostrum near its distal end on either side are one or two, usually two, short stout mobile spines. The spines of the two sides are not symmetrically placed, those of one side occurring in advance of those of the other.

The antennal angle is unarmed, although it is not rounded. The ocular stylets are very short.

The pleonic somites are sculptured as follows: The first segment is grooved by a complete posteromedian pleural sulcus and a short anteromedian one which is obliterated a short distance ventrad its juncture with the anterior margin of the pleuron. Some distance below the point of obliteration a barely perceptible short continuation of the anteromedian pleural can be made out. The second and third somites bear an anterior tergal and a short posterior one;

a short shallow anteromedian pleural, and a posteromedian pleural which, somewhat above the middle of the lateral surface, turns sharply anteriorad. The longitudinal terminal portion of this sulcus is margined above by a low but perceptible ridge. The fourth and fifth segments bear a posterior tergal and an anterior one which is obliterated for a considerable interval below its short dorsal section, reappearing farther ventrad. The sixth somite bears the usual two sulci here regarded as anterior tergal and posteromedian pleural, as well as the longitudinal sulcus.

There is a deep cleft in the dorsal carina of the second somite, above the juncture of the tergal sulci and directly in line with the anterior of them. The posterior end of the dorsal carina of the fifth somite slopes gently to the apex of the cleft in the posterodorsal margin, without a sharp dentiform descent. The ventral pleural margins are rounded except for a posterior tooth on the fifth and sixth somites. The surface of the pleon is punctate but not rugose or tuberculate. The telson bears a pair of large, conspicuous fixed teeth; there is also in these small Pacific specimens, an anterior pair of mobile spines.

The petasmal endopods of the two minute males are completely united. The distolateral projections do not converge toward one another, but are strongly curved anteriorad. The distoventral projections taper strongly beyond an expanded basal portion, and are directed distad; while their distalmost portions are folded back proximad. The lateral edges of the petasma are deeply and conspicuously notched at a point somewhat nearer to its proximal than to its distal end.

The tip of the external scale of the basal segment of the antennular peduncle does not reach forward farther than to the fringe of setae posteriorly bounding the anteromedian naked area of the article.

In the Atlantic material examined for comparison with the Pacific, the posterior of the postorbital teeth of the carapace ranges from 23 to 36%, mean, 29.5%; and the middle tooth from 51 to 64%, mean 57%, anterior to the posterior margin of the carapace. The anterior tooth is from 4 to 15%, mean 10%, posterior to the orbital margin; and from 8 to 20%, mean 12%, anterior to the level of the hepatic spine. In all save one small male the distance between the anterior and the middle tooth is greater than that between the middle and the posterior tooth. The distance between the anterior postorbital tooth and the posteriormost rostral tooth ranges from 4 to 16%, mean 9%, less than the distance between the anterior and the middle tooth of the carapace.

The rostrum is elevated at an angle ranging from horizontal in the smallest specimen to about 35° elevation above the horizontal, the usual angle being over 20°. Its length ranges from 41% in the very minute specimen, to 59% of the carapace, some increase in relative length with increase in size seeming to occur. Excluding the largest and the smallest specimen; that is, within a size range of 3 to 6.5 mm carapace length, the rostral length ranges from 50 to 60%, the mean being 55%.

The posterior rostral tooth ranges from 9 to 17%, mean 13.3% anterior to the orbit; the third tooth from less than 4 to 8% behind the anteriorly directed tip of the fourth tooth. The second tooth is usually placed slightly posterior to the midpoint between the first and third. In the largest specimen the distal end of the rostrum bears five teeth (including the third tooth from the base); in three smaller specimens it bears three teeth; in the remainder, four.

In all specimens except the largest one, which appears to exceed any previously recorded maximum, the telson bears a pair of mobile lateral spines just distad the basal shoulders. Since all except the smallest female appear to be sexually mature, or at least, impregnated, the presence of these mobile lateral spines cannot be considered as a juvenile character, although they are evidently lost in the later course of adult existence.

It has apparently never been observed that *Eusicyonia laevigata* is almost indistinguishable from *E. carinata* (Oliv) of the Eastern Atlantic and Mediterranean, although De Man, 1907 and 1911, in designating as *Sicyonia carinata americana* an *Eusicyonia* from Brazil which evidently represents *E. laevigata*, indirectly acknowledges this similarity. By no described character can De Man's material be distinguished from *E. laevigata*, with which he fails to compare it, while at the same time his description of the anterior tooth of the carapace as much smaller than the two following and than the corresponding tooth in Mediterranean material; and of the third rostral tooth as placed immediately behind the tip, clearly does not apply to *E. parri*, n. sp., to be described in a further paragraph.

The foregoing material of *E. laevigata* has been compared with three males and three females of *E. carinata* from Messina, the examination of which was very kindly permitted by the Museum of Comparative Zoology. These specimens range from 8.7 to 17.9 mm in carapace length, the largest, about 72 mm in total length, being more than 10 mm longer than the known maximum as given by De Man, 1911. The anteriormost tooth of the carapace of *E. carinata* seems relatively larger than that of *E. laevigata*, although it is conspicuously smaller than the two posterior teeth. It is constantly placed far anterior to the level of the hepatic spine, at an average of 14.6% (range 12.4 to 15.8%) behind the orbital margin, and 32.6% (range 30 to 36%) anterior to the middle tooth. The anterior tooth is 6.3% (range 2.8 to 10.8%) farther from the middle tooth than is the latter from the posterior tooth. The rostrum of *E. carinata*, ranging from the horizontal to 10°, is less elevated than is that of *E. laevigata*. It generally bears three dorsal teeth, the anterior of which is generally much further behind the bi- or trifurcate tip than in *E. laevigata*, and the posterior of which seems relatively closer to the orbital margin than in the American form. The ventral tooth of the rostrum is generally placed much farther proximad the elongate terminal portion than is that of *E. laevigata*.

The median concavity of the posterior margin of sternite XIII of the female of *E. carinata* seems much shallower than that of *E. laevigata*. The petasma is

very similar to that of the American form, but with shallower midlateral notches (which are, incorrectly, not represented in the figure by Pesta, 1918), and with distolateral projections somewhat convergent as well as curved dorsally. The sharpest distinctions between the two species are provided by the pleonic sculpture. In *E. carinata* the pleonic integument is heavily wrinkled and the sulci are very deep. The anteromedian pleural sulcus of the first pleonic somite is continued without interruption to the ventral margin, being joined somewhat above the margin to the posteromedian pleural. There are rather poorly marked posterior pleurals on the first, second and third somites. The posterior tergals of the second and third somites extend more strongly below the level of the dorsal end of the posteromedian pleurals. The anterior tergal of the fourth somite extends ventrally without any obliteration of its midportions.

It may be noted that those among the specimens described as *E. laevigata* by Rathbun, 1901, with "six dorsal teeth instead of five" probably pertain to *E. parri*, n. sp.

***Eusicyonia parri*,¹ new species**

Figure 22, page 72.

1 female, holotype. B.O.C. 75. Crooked Island, Bahamas, seine, March 26, 1927.

Dimensions—carapace length 6.3 mm, total length 24.5 mm.

In addition to the holotype, a small damaged female from Tallaboa, Puerto Rico, in the collection of the American Museum of Natural History, has been available. The pleon of this specimen measures 7.8 mm in length, so that the missing carapace was probably about 2.5 mm in length, excluding the rostrum.

Description—Postrostral carina bearing three large subequal teeth of which the anteriormost, placed only slightly in front of the level of the hepatic, is considerably larger than the teeth of the rostral series, and is 2% closer to the middle tooth of the carapace than to the posterior tooth of the rostrum. The posterior tooth is 29%, the middle tooth 55% anterior to the posterior margin. The anterior tooth is 22% from the orbital margin and 4% in advance of the hepatic spine; the distance from the anterior to the middle is less than that from the middle to the posterior tooth.

The rostrum, 52% of the carapace in length and 12% in depth just in front of the posterior tooth, is elevated at an angle of about 15°. It bears three teeth behind the terminal portion, of which the posteriormost is 1% anterior to the orbital margin. The second rostral tooth is placed somewhat closer to the posterior than to the third rostral tooth. The third tooth is placed 20% behind the distalmost extension of the rostrum. The terminal portion of the rostrum bears three teeth, between the middle and the ventralmost of which the rudiment

¹ Named for Professor Albert Eide Parr.

of a fourth tooth is visible. There are no mobile spinules on the ventrodistal margin of the rostrum.

The tip of the telson is broken; a pair of mobile lateral spines is present.

The emargination of the posterior margin of the thirteenth pereionic sternite is shallower than in any females of *E. laevigata*, and considerably shallower than in the larger specimens comparable in size with the representative of *E. parri*.

The first pleonic somite bears a short anteromedian pleural, like that of *E. laevigata*. A little below the point where the groove disappears, however, it reappears and is conspicuously continued nearly to the ventral margin. It does not join the posteromedian pleural ventrally. The first and second pleonic somites bear a shallow but readily perceptible posterior pleural sulcus. The dorsal and ventral portions of the anterior tergal of the fourth somite are separated by a very narrow area of obliteration.

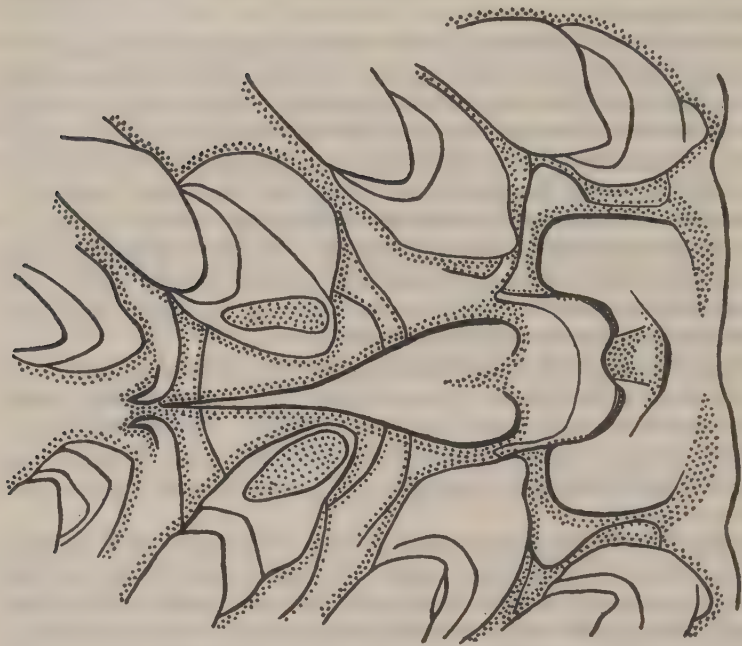
The minute and imperfect Puerto Rican female has a posterior pleural sulcus faintly indicated on the first two pleonic somites. The anteromedian pleural of the first somite is conspicuously continued ventrally. The emargination of the posterior margin of the thirteenth pereionic sternite seems shallower than in comparable small females of *E. laevigata*. It is probable that this individual pertains to *E. parri*.

Eusicyonia parri, although very similar to both *E. laevigata* and *E. carinata*, differs from both in a number of characters. The anterior tooth of the carapace is relatively much larger than in either of the other two species, and is placed much closer to the middle tooth and much farther from the orbital margin, as well as less in advance of the level of the hepatic spine. The posterior tooth of the rostrum is placed much nearer the base than in *E. laevigata*, and somewhat nearer than in *E. carinata*; the third tooth conspicuously farther behind the tip than in *E. laevigata*, while the ventral rostral tooth is placed nearer the tip than in *E. carinata*. The posterior pleural sulci of the anterior pleonic somites, and the strong ventral continuation of the anteromedian pleural of the first somite, clearly distinguish *E. parri* from *E. laevigata*, while the smooth integument, shallower sulci, shorter second and third posterior tergals, and conspicuously interrupted first anteromedian pleural and fourth anterior tergal clearly differentiate it from the more nearly similar *E. carinata*.

I have no hesitation in describing *E. parri* from a single perfect specimen and the pleon of another, since two Pacific examples in very complete agreement with the Atlantic form except by their lack of the posterior pleural sulci are available, and will be described below as *E. disparri*, n. sp.

It is probable that some of the material reported by Rathbun, 1901, as *E. laevigata*, pertains to *E. parri*.

E. parri resembles in some respects the Indo-Pacific *E. trispinosa* De Man. In the figure of that species, however, the third rostral tooth is shown as considerably behind the level of the hepatic spine; the dorsal carina of the second pleonic somite is not notched; the antennal angle is more obtuse; and there are



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probably other differences. It may be noted that although De Man speaks of only two transverse sulci on the first pleonic somite of *E. trispinosa*, as in *E. carinata*, his figure shows, as in *E. parri*, a third, posterior pleural, sulcus.

***E. disparri*, new species**

Figure 27, page 82.

2 females, type and cotype. *B.O.C.* 73. Gonzaga Bay, Lower California, seine, May 17, 1926.

Dimensions—Type, carapace length 9.3 mm; cotype, 9.2 mm. Type, total length 44 mm; cotype, 42 mm.

Description—Posterior postrostral tooth of the type 25, of the cotype 27% anterior to the posterior margin of the carapace; middle tooth of the type 52, cotype 54% anterior to the postmargin; anterior tooth 25 and 22% behind the orbital margin, closer to the middle tooth of the carapace than is this to the posterior tooth, not placed anterior to the level of the hepatic spine, and 0 and 4% closer to the middle tooth of the carapace than to the posterior rostral tooth.

The rostrum is elevated at an angle of about 35°. In the type it is somewhat under 50, in the cotype 47% of the carapace in length. Its depth just in front of the posterior tooth is in both specimens 16% of the carapace length. The basal "rostral" tooth is in the type actually behind the orbital margin by 2%; in the cotype it is 2% anterior to the orbital margin. The second rostral tooth is closer to the third than to the basal tooth. The third rostral tooth is in the type 15, in the cotype 13% behind the ultimate extension of the rostrum. In both specimens, there is a single mobile spinule on either side of the ventro-distal margin of the rostrum. There are in the type four terminal teeth and the rudiment of a fifth; in the cotype five terminal teeth.

The anterior two pleonic somites lack a posterior pleural sulcus. The fourth somite of the type is armed with a short posterior ventral tooth. The telson of the type lacks, while that of the cotype bears, a pair of mobile in addition to the pair of fixed lateral spines.

Eusicyonia disparri seems to be identical with *E. parri* save in the absence of a posterior pleural sulcus on the anterior pleonic somites and in the shorter, deeper and more elevated rostrum. The loss of the pleural sulcus is, curiously enough, paralleled in other Pacific species as compared with their Atlantic congeners. It is probably a character of sufficient constancy to be regarded as specifically distinctive.

There is some superficial resemblance between *E. parri* and *E. disparri*, and *E. brevirostris*, in that the posterior tooth of the rostrum of the former two

Figure 26. *Eusicyonia laevigata* (Stimpson).

Thelycum of the largest female (Puerto Rico) $\times 10.4$.

Figure 27. *Eusicyonia disparri*, n. sp.

Thelycum $\times 10.4$.

species is placed so close to the orbital margin, and the large anterior tooth of the carapace so close to the level of the hepatic spine that individual variation sometimes carries these teeth posterior to the levels which, for convenience, I have arbitrarily selected as critical, thus reproducing the carapacic dental formula of *E. brevirostris*. Since, however, the distinctions between the species include those given as distinguishing Division I from Division II, confusion is impossible. The posterior shift of the carapacic teeth of *E. parri* and *E. disparri*, relative to *E. carinata*, seems to parallel the shift which has occurred on a more extensive scale in such Indopacific members of the Division as *E. lancifer*.

DIVISION II

Eusicyonia brevirostris (Stimpson)

Sicyonia cristata, DE SAUSSURE, 1858 (not *S. cristata* DE HAAN, 1850).

Sicyonia brevirostris, STIMPSON, 1871; MILNE EDWARDS and BOUVIER, 1909.

Sicyonia edwardsi, HAY and SHORE, 1918; BOONE, 1927, part.

1 male, carapace 18.1 mm, total length 70 mm. *B.O.C.* 79. Off the Pacific coast of southern Mexico (lat. 14/40/20 N., long. 92/40/30 W.), trawl, April 9, 1926.

1 male, carapace 24.2, total length 82 mm. *B.O.C.* 78. Green Cay, Bahamas, stomach of *Mycteroperca venenosa*, March 17, 1925.

In addition to the above, the examination of a small male 8.9 mm in carapace and 45 mm in total length from off the coast of North Carolina in 27 fathoms has very kindly been permitted by the American Museum of Natural History; and of a male 15.2 mm in carapace length, four females ranging from 12.1 to 14.4 mm in carapace length, and a very small individual 5.3 mm in carapace length, of which the pleon is unfortunately missing, from the Straits of Florida, by the Museum of Comparative Zoology. These latter specimens have been previously reported by Milne Edwards and Bouvier, 1909. A small female, 6.0 mm in carapace length, from the Yucatan Bank, was also loaned by the Museum of Comparative Zoology.

Eusicyonia brevirostris has not been previously known to occur on the Pacific coast of America. No significant differences between the Pacific specimen and the nine Atlantic ones was ascertainable.

The Pacific specimen affords the following description: dorsal carina of the carapace high, cut into four teeth behind the orbital margin, of which the posteriormost is 25.4% of the carapace length anterior to the posterior margin; the penultimate 20.4% from the ultimate; the antepenultimate 26.4% anterior to the penultimate and 5% posterior to the level of the hepatic spine; and the anteriormost 22% in advance of the antepenultimate and 5% behind the orbital margin. A line through the tips of these teeth is convexly curved, its

highest point occurring at the penultimate tooth. The anteriormost tooth, in size, shape, and position, except that it lies behind the orbital margin, falls into the rostral series.

The short and slender rostrum, narrowing considerably to its tip, is 20% of the carapace in length. It bears two teeth behind the bifurcated terminal section, of which the posterior is about 5% from the orbital margin. The ventral terminal tooth extends farther distad than does the dorsal.

The antennal angle is armed with a small spine. The ocular stylets are long.

The pleon is heavily tuberculate. Its sculpture is as follows: The first somite is cut by complete anteromedian and posteromedian pleurals, a posterior pleural, and a posterior tergal. The second and third somites bear two tergals, two median pleurals which extend very far dorsad, and a posterior pleural. The fourth somite bears three sulci which are probably to be interpreted as a short posterior tergal, an anterior tergal joining ventrally with a shallow anteromedian pleural, and a long posteromedian pleural reaching very far dorsad. The fifth somite bears an anterior and a long posterior tergal; the sixth a posteromedian pleural, an anterior tergal, and a longitudinal sulcus.

The pleura of the first four somites are armed with an anterior ventral angle which is produced on the third and fourth into a blunt spine. The last three somites are armed with a posterior ventral tooth. The posterior end of the dorsal carina of the fifth somite is damaged, but appears to have descended to the cleft as a conspicuous though not produced tooth.

The tip of the telson is damaged but the traces of a pair of fixed lateral spines are visible.

The petasma very closely resembles that of *E. edwardsi*.

In the Atlantic material examined, no variation in pleonic sculpture was detected, except that the tuberculation becomes weaker, the angle at the posterior end of the dorsal carina of the fifth somite less sharp and high, and the produced teeth of the ventral pleural angles weaker (to the point of disappearance) with decreasing size.

A fairly considerable amount of variation in the position of the teeth of the carapace occurs, which displays no clear correlation with size, although it is possible that the teeth tend to shift somewhat posteriorly with growth. The posterior tooth of the carapace ranges from 23 to 28.4%, mean 25.5%, in front of the posterior margin; the penultimate tooth from 19.1 to 24.4%, mean 22%, in front of the posteriormost. The antepenultimate tooth ranges from 26.8 to 35.2% in front of the ultimate, the average being about 30%. The fourth or anteriormost tooth which occurs on the carapace is not constantly behind the orbital margin and indeed ranges from 5.7% behind the margin to 7.4% in advance of it without any clear correlation with size of individual being apparent. This tooth ranges from 20 to 29.8% in advance of the antepenultimate. The posterior rostral tooth ranges from 3 to 25% in advance of the orbital margin, or 9 to 18% in advance of the fourth tooth.

The rostrum of the six specimens in which it is unbroken (which do not include either the largest or the smallest individuals) ranges in length from 30 to 55% of the carapace, and is elevated at an angle to the carapace of from about 5° to 45°. It constantly bears two teeth in advance of the tooth which ranges behind the orbital margin; and the tip may be armed with either two or three teeth.

It seems probable that Bouvier is incorrect in regarding the interpolated third tooth of the rostral tip as characteristic of young specimens; it seems more likely that, as in *E. edwardsi*, the tooth may be present or absent without relation to size. Bouvier's suggestion that the rostrum decreases in length and elevation with increase in size of the individual appears to be correct; it may be noted, however, that this change is highly irregular, and that there seems to be a greater range of individual variability in this character in *E. brevisrostris* than in any other species of *Eusicyonia* which I have examined. It is noteworthy that the antepenultimate tooth of the carapace is constantly anterior to the hepatic spine over a considerable size-range in material from the Straits of Florida; constantly behind it in the material from other localities. I see no reason to disagree with Bouvier's conclusion, that the type of *E. cristata* (De Saussure) and that of *E. brevisrostris* (Stimpson) are specifically identical.

***Eusicyonia disedwardsi*, new species**

Figures 23, page 74; 29, page 87; and 34, page 91.

1 male, holotype. *B.O.C.* 72. Concepcion Bay, Lower California, May 3, 1926.

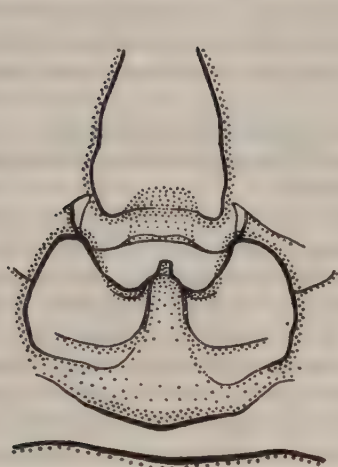
Dimensions—Carapace length 10.4 mm, total length 42 mm.

Description—Postrostral carina bearing three teeth behind the orbital margin, of which the posteriormost is 26% of the carapace length from the posterior margin; the middle tooth 36% from the orbital margin and well posterior to the hepatic spine; the anteriormost 2% from the orbital margin. Behind the posterior tooth the middorsal carina of the carapace is high; anterior to it the carina is lower, descending again at the smaller middle tooth to the still lower carina which culminates in the anteriormost tooth of the carapace. This latter, which is about equivalent in size to the rostral tooth anterior to it, is much smaller than the two teeth behind the level of the hepatic spine.

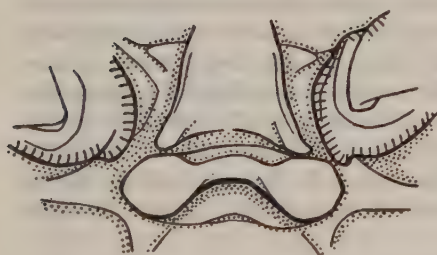
The rostrum narrows considerably from the base to the bifurcate tip. The dorsal margin of the rostrum bears three teeth behind the two terminal ones. It is elevated at a very considerable angle to the dorsal margin of the carapace, about 35°. Its length is about 26% of that of the carapace.

The pair of median stylets borne by the ocular somite are divergent, being bent conspicuously laterad near their tips.

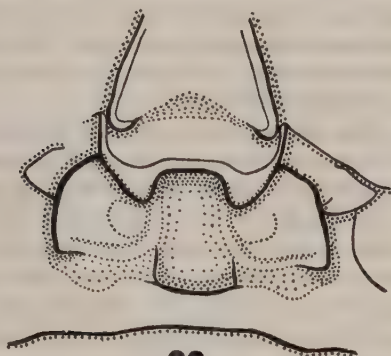
The pleonic sculpture most nearly resembles that of *E. penicillata*. The an-



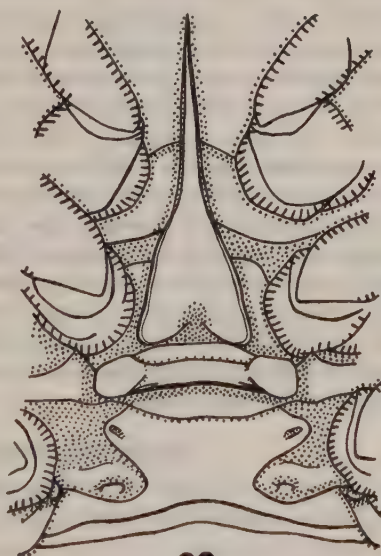
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Figure 28. *Eusicyonia edwardsi* (Miers).
Thelycum $\times 13$.

Figure 29. *Eusicyonia disedwardsi*, n. sp.
Male genital sternites $\times 13$.

Figure 30. *Eusicyonia penicillata* (Lockington).
Thelycum $\times 13$.

Figure 31. *Eusicyonia penicillata* (Lockington).
Male genital sternites $\times 13$.

terior four pleonic somites lack more than the faintest trace of a posterior pleural sulcus. The first somite lacks even a trace of a posterior tergal, and the dorsal portion of the posteromedian pleural is obliterated. The pleura of each of the anterior four somites are armed with acute anterior ventral angles flared somewhat outward. The pleura of the fifth and sixth somites are armed with a posterior ventral tooth.

The telson bears a pair of small but conspicuous fixed lateral spines.

The posterior margin of pereionic sternite XIII is slightly concave, but without any deep and conspicuous median emargination.

The pair of laterodistal projections of the petasma are short, with antrorse tips, and do not bear any trace of accessory filaments. The distoventral projections are short and stout, with proximally turned tips. In this single available specimen, the petasmal endopods are not yet completely hooked together proximally, and the individual is to be considered as subadult.

In all its characters *E. disedwardsi* seems practically identical with the Atlantic American *E. edwardsi* (Miers) except in the obsolescence of the posterior pleural and other sulci. In this latter character it resembles the related Pacific coast species, *E. penicillata* (Lockington). It is described as a new species with some hesitation, since, being smaller than any available individual of *E. penicillata*, the possibility is present that it represents the juvenile form of that species. However, since all evidence indicates that modification of structure is more or less negligible from the smallest to the largest individuals with joined petasmal rami or impregnated thelycum, and since in particular *E. penicillata* shows no tendency to change in the direction of *E. disedwardsi* down to sizes not greatly larger than the holotype of that form, it seems a defensible conclusion that *E. disedwardsi* is a distinct species. The fact that *E. penicillata* is very much more different from *E. edwardsi* than are other Pacific species of *Eusicyonia* from their Atlantic congeners may indicate that *E. disedwardsi* is the Pacific representative of the Atlantic form, while *E. penicillata* is a more divergent offshoot of the same stock.

***Eusicyonia penicillata* (Lockington)**

Figures 30 and 31, page 87; figure 33, page 91.

Sicyonia penicillata LOCKINGTON, 1879; SCHMITT, 1924c; BOONE, 1930.

4 males, 2 females. *B.O.C.* 83. Bay San Felipe, Lower California, seine, May 19, 1926.

6 males, 15 females. *B.O.C.* 84. Angeles Bay, Lower California, otter-trawl, 17 to 23 fathoms, May 13, 1926.

35 males, 25 females. *B.O.C.* 85. Concepcion Bay, Lower California, otter trawl, May 3, 1926.

Size range in carapace length of the above material is, males, 12.1 to 20.1 mm; females, 10.7 to 23.0 mm.

E. penicillata may be characterized as follows: There are three teeth on the

dorsal carina of the carapace behind the orbital margin. Of these the anteriormost is placed close to the posteriormost rostral tooth and is about equivalent to it in size, being much smaller than the two teeth behind the level of the hepatic spine. The anterior tooth is usually placed about 5% of the carapace length behind the orbit, the range being from 1 to 8%. There is no perceptible change in the relative position of this tooth with differences in sex or size. The middle postorbital tooth, which is always well behind the level of the hepatic spine, averages 38% of the carapace length behind the orbital margin, but is quite variable in position within a range of from 33 to 43%. Its position displays no clear correlation with sex or size of the individual. The posterior tooth is usually placed about 26% of the carapace length from the posterior margin. It is perhaps placed slightly farther anterior in males than in females and in small than in large individuals, but this correlation, if real, is rather effectively masked by the considerable degree of individual variation. The range of position of the posterior tooth is from 23 to 30% anterior to the posterior margin. There is some evidence of a correlation between the positions of the posterior and middle teeth; when the former fall anterior or posterior to their modal distances from the posterior margin, the latter tend to be placed respectively nearer to or farther from the orbit; or, in other terms, the distance between the two teeth seems to remain more constant than the distance from the margin of either tooth.

The rostrum ranges in length from 11 to 25% of the carapace length. It is longer in small than in large individuals and in females than in males. The modal rostral length of males below 16.5 mm in carapace length is 15%; above this length, 17%; of females below, 16%; of females above, 19%. The rostrum varies in elevation from horizontal to about 30°, the angle usually being slight. The breadth decreases from base to tip, occasionally very conspicuously. The dorsal margin generally bears one tooth behind the bifurcate distal part, but in about one individual out of ten there is an additional tooth behind the two terminal ones, often close enough to them to create the appearance of a trifurcate tip.

The ocular stylets are sometimes bent very slightly outward at their tips, but never to a noticeable extent. The stylets are relatively longer in large than in small individuals, and may extend to the median base of the corneal surface.

The tuberculate pleonic terga and pleura are sculptured as follows: The first somite bears an anteromedian pleural which is continued without break nearly to the ventral margin; as well as a posteromedian pleural the dorsal end of which reaches the anterior margin; and a faint trace of a posterior tergal. The second and third somites bear two tergals, two median pleurals which extend far dorsad, and a very faint trace of a posterior pleural. The fourth somite bears a shallow, short posterior tergal, a long anterior tergal, and a very long posteromedian pleural meeting the joined tergals dorsally. The fifth somite

bears an anterior tergal and a posterior pleural which joins it dorsally. The sixth somite bears two similar sulci, which respectively extend along the dorsal and anterior margins of the somite, and the ventral and posterior ones; in addition to a deep longitudinal sulcus on the tergum of either side.

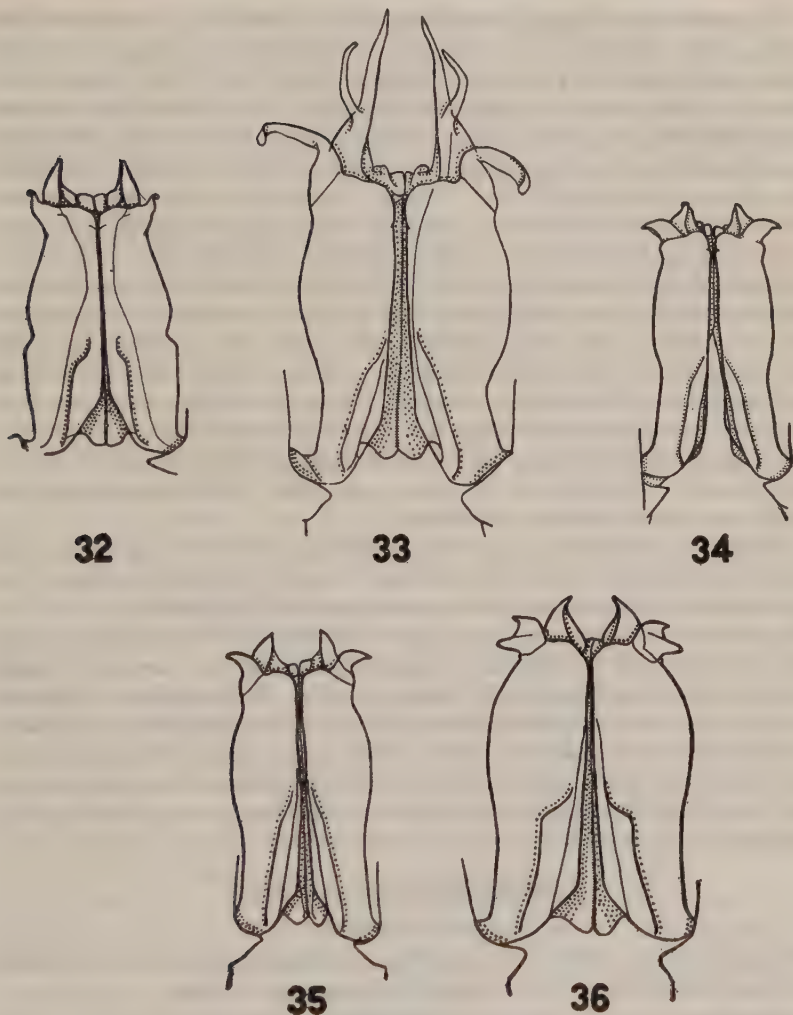
The first to fourth pleonic somites are armed with an acute anterior ventral angle, the angles of the third and fourth somites being somewhat produced as laterally directed spines. The fifth and sixth, and occasionally the fourth, somites are armed with posterior ventral spines. This armature becomes relatively stronger with increasing age.

The telson bears a usually conspicuous pair of fixed lateral teeth.

The posterior margin of the thirteenth pereionic sternite of the male is deeply but rather broadly emarginate in the middle. In the female the emargination in a similar position is extremely narrow, although relatively as well as absolutely somewhat broader in small than in large individuals. The maximum breadth of the female emargination is less than 0.3 mm, the minimum about 0.1 mm.

The petasma seems to be unique in a genus marked by considerable uniformity in this structure. Both pairs of distal projections are produced to extremely long, slender and pliant tips, the total length of the distolateral projection being over half that of the remainder of the endopod. From the thickened base of this lateral projection a slender filament springs which is as long as from one-half to two-thirds the distance from its point of origin to the tip of the projection proper. The petasma shows no change in form from the smallest to the largest available males, in all of which, however, the endopods are completely united.

As compared with four males of *E. edwardsi* (Miers) ranging from 11.3 to 19 mm in carapace length and five females ranging from 13.4 to 15.0 mm, *B.O.C.* 82, Isle of Pines (*E. edwardsi*, part, Boone, 1927), the following differences are perceptible: The middle tooth of the postrostral carina seems usually to be placed slightly closer to the orbital margin in *E. edwardsi*. The anterior tooth is usually placed closer to the orbital margin than in *E. penicillata*, never more than 3% of the carapace behind, and in a few cases above or anterior to the margin. The rostrum is longer, the range in length being 21 to 33%, and the mean 26%. The elevation of the rostrum is generally somewhat greater. The ocular stylets diverge strongly at their tips. The pleonic sulci are much stronger, and a conspicuous posterior pleural occurs on the first four somites. The fixed lateral spines of the telson are smaller, and are occasionally no more than vestigial. The distal projections of the petasma lack elongated tips, and the lateral pair do not bear accessory filaments. The posterior margin of the thirteenth pereionic sternite of the male lacks a deep median emargination; the emargination in the female (figure 28, page 87) is much wider, ranging between .55 and .7 mm. The setae of the various pubescent structures are less long and dense than are those of large specimens of *E. penicillata*, in which species the density of pubescence increases with increasing size.



- Figure 32. *Eusicyonia laevigata* (Stimpson).
Petasma of a male from the Pacific coast of Panama, ventral view $\times 28.5$.
- Figure 33. *Eusicyonia penicillata* (Lockington)
Petasma, ventral view $\times 13$.
- Figure 34. *Eusicyonia disedwardsi*, n. sp.
Petasma, ventral view $\times 13$.
- Figure 35. *Eusicyonia picta* (Faxon).
Petasma, ventral view $\times 13$.
- Figure 36. *Eusicyonia disdorsalis*, n. sp.
Petasma, ventral view $\times 13$.

The examination of a very small male of *E. edwardsi*, 6.1 mm in carapace length, in the collection of the Museum of Comparative Zoology, one of the Blake specimens from Flannegan Passage reported by Milne Edwards and Bouvier in 1909, gives the following evidence as to variation with size in species of the *edwardsi* group: The petasmal endopods are in this specimen completely hooked together, the petasma being identical with that of larger specimens. The pleon is identical with that of larger individuals except that its surface is less conspicuously tuberculate, and that the anterior ventral pleural angles of the third and fourth somites are not produced. The transverse ridge behind the spine of the thirteenth pereionic sternite is relatively wider and shorter than that of the larger adults, and with a perhaps somewhat more concave posterior margin. The ocular stylets are shorter but are as in the large specimens conspicuously divergent at their tips. The antennal spine, as usual in small specimens of *Eusicyonia*, is weaker. The posterior tooth of the carapace, at 30.3% from the posterior margin, is 2% farther anterior than is the extreme in the larger specimens; the middle tooth, at 34.1%, is 1% closer to the posterior tooth than is the extreme in the larger specimens. Other measurements fall within the range of the larger specimens.

As has been previously mentioned, *E. disedwardsi* Burkenroad differs from *E. penicillata* precisely as does *E. edwardsi* save that its pleonic sulci seem to be even shallower and less complete than are those of *E. penicillata*.

It may be noted in passing that *Sicyonia edwardsii* of Hay and Shore, 1918, from Beaufort, North Carolina, purportedly the farthest northern record, actually refers according to the figure given, to *E. brevirostris* (Stimpson).

Contrary to the statements of Milne Edwards and Bouvier, 1909, the cardio-branchial ridge of *E. edwardsi* as well as of the two related Pacific species is continuous with the buttress of the hepatic; the ocular stylets may reach to the base of the cornea in large individuals; and there is occasionally a small posterior ventral tooth on the fourth pleonic somite.

***Eusicyonia aliaffinis*, new species**

Figure 24, page 74.

1 male, holotype. *B.O.C.* 74. Pacific coast of southern Mexico (lat. 14/48/40 N., long. 92/54/40 W.), trawl, 19 to 30 fathoms, April 9, 1926.

Dimensions—Carapace length 8.7, total length 34.5 mm.

Description—The anterior postrostral tooth is 18% of the carapace length, the posterior 71%, behind the orbital margin. The carina between these teeth is relatively higher than in *E. picta* or *E. disdorsalis*; it is conspicuously elevated in advance of the posterior tooth, which is very high. The posterior margin of the posterior tooth slopes to the hinder edge of the carapace as a high carina. The anterior tooth, like the rostrals to which it is subequal in size, is larger than the anterior tooth found in *E. picta* or in *E. disdorsalis*, and is placed barely in front of the level of the hepatic spine rather than well before it.

The rostrum is about 37% of the carapace in length, and is elevated at a considerable angle, about 30°. It bears two teeth behind the terminal part, the posterior of which is 4% of the carapace length in advance of the orbital margin. The anterior tooth is 17% from the end of the rostrum. The anterior end is obliquely truncate, the more projecting ventral and shorter dorsal margins ending in a short tooth, while between them a third tooth, now broken, appears to have existed.

The ocular stylets are like those of *E. picta*.

The pleonic sculpture is as follows: The first somite bears deep anteromedian and posteromedian pleural sulci, both of which are complete, joining near the ventral margin of the pleuron. The second and third somites bear two tergal, and two median pleurals the anterior of which is much deeper and longer than that of *E. picta*; all four sulci being deeply incised. The fourth somite bears an anterior and posterior tergal which extend to the ventral margin where they meet; the fifth somite a long posterior and a short anterior tergal; the sixth an anterior tergal, a posteromedian pleural, and a deep longitudinal sulcus. The pleon is rugose and tuberculate.

There is an anterior ventral angle on the first to fourth pleonic somites, a trace of a posterior ventral angle on the fourth, and a posterior ventral spine on the fifth and sixth somites.

The posterior end of the dorsal carina of the fifth somite of the pleon descends sharply to the apex of the cleft, but is not produced into a tooth. A similar but smaller angle occurs on the fourth somite. The carina of the second somite is, although not notched above the juncture of the tergal sulci, shallowly emarginate at this point. The tooth of the anterior end of the carina of the first somite is more elevated than in *E. picta*, and the anterior margin of the tooth descends vertically rather than in an overhanging oblique.

The telson is armed with a pair of small but conspicuous fixed lateral teeth.

The petasma endopods of the holotype are not united. The distolateral and distoventral projections are short and slender, and are not furcate.

E. aliaffinis is very closely related to *E. affinis* (Faxon), a species known from Malpelo and Cocos Islands in depths of from fifty-two to one hundred and twelve fathoms. Three specimens of *E. affinis*, evidently male and female cotypes and a female paratype, in the collection of the Museum of Comparative Zoology, have been available for examination.

Faxon, 1895 is in error in regarding *E. affinis* as the Pacific American representative of *E. edwardsi*. Although *E. affinis* and *E. aliaffinis* display a general resemblance to the *edwardsi* group, they differ in bearing only two postrostral teeth, only one of which lies behind the level of the hepatic spine. This dentition is quite similar to that of the *E. dorsalis* and *E. stimpsoni* groups of species. An Indopacific form, *E. benthophila* (De Man) appears closely to resemble *E. affinis*, but bears a basal and ischial armature on the first legs. There is no known Atlantic congener of *E. affinis* and *E. aliaffinis*.

E. aliaffinis differs from *E. affinis* most conspicuously in the characters of its pleon, which is practically indistinguishable from that of *E. disedwardsi*. In *E. affinis* the first pleonic somite bears a shallow anteromedian pleural sulcus extending less than one-fourth of the distance from its point of origin to the ventral margin. This sulcus is in *E. aliaffinis* deep and complete, extending almost to the ventral margin to meet the posteromedian pleural. In *E. affinis* the posteromedian pleural sulci of the second and third somites extend dorsally only to within a third of the distance between the dorsal midline and ventral margin from the dorsal midline; the sulci turn anteriorad at their dorsal ends and are margined above by a low longitudinal ridge. In *E. aliaffinis* the posteromedian pleural sulci extend to within a fourth from the dorsal midline, and do not turn anteriorly. The anteromedian pleural sulci of the second and third somites of *E. affinis* are broad and shallow and do not reach nearly as far dorsad as the short posteromedian pleurals. In *E. aliaffinis* the anteromedian pleurals are deep and well-marked and nearly meet the posteromedian pleurals dorsally.

The posterior end of the dorsal carina of the fifth somite of *E. affinis* descends no more sharply than that of the fourth somite in *E. aliaffinis*, while the carina of the fourth somite in *E. affinis* slopes gently downward behind without any angular descent at all.

The ventral margins of the pleura of *E. affinis*, stated by Faxon to be broadly rounded, display a faint trace of an anterior angle on the first to fourth somites, much weaker, especially on the first somite, than the corresponding angles in *E. aliaffinis*. There is no trace in *E. affinis* of the posterior ventral angle of the fourth somite which is present in the holotype of *E. aliaffinis*.

The pleonic surface of *E. affinis* is punctate and setose, but smooth; not wrinkled and tuberculate as in *E. aliaffinis*.

The carapace of the two species is very similar. The dorsal carina of the female paratype of *E. affinis*, behind the margin of the posterior tooth, is lower than that of *E. aliaffinis*; the anterior tooth of the carapace is relatively nearer to the orbital margin; the rostrum is shorter and less elevated, and the posterior rostral tooth placed farther in advance of the orbital margin; the antennal spine is much less stout and without so marked a buttress as in *E. aliaffinis*, but it is possible that there is sufficient variation in these characters to make them of little critical value.

The transverse ridge near the posterior margin of the fourteenth sternite of the male of *E. affinis* is much wider and shorter and is more arched than that of *E. aliaffinis*, and the lateral, longer portions of it do not extend as far mediad.

The petasma of the adult male type of *E. affinis* resembles that of *E. edwardsi*.

Since the only known specimens of *E. affinis* are large adults, while the holotype of *E. aliaffinis* is much smaller and is juvenile, there exists a possibility that the latter may represent a developmental stage of *E. affinis*, and not a distinct species. However, in all species of *Eusicyonia* of which a considerable size

range has been available to me, the sulci of the pleon are very constant, and, if they change at all, merely grow relatively deeper with increase in size; the pleural armature increases both in strength and extent with growth; and the rugosity of the integument becomes more pronounced. I therefore feel that the considerable differences displayed by the specimen here described as *E. aliaffinis* represent specific distinctions, and that, as in a number of other Pacific American forms, closely related but distinct northern and southern species exist.

***Eusicyonia picta* (Faxon)**

Figure 35, page 91.

Sicyonia picta FAXON, 1893 and 1895.

1 female, carapace length 10.3 mm. *B.O.C.* 80. Angeles Bay, Lower California, 17 to 23 fathoms, May 13, 1926.

1 male, carapace length 11.5 mm. *B.O.C.* 81. Gonzaga Bay, Lower California, seine, May 17, 1926.

E. picta presents the following characteristics as compared with *E. disdorsalis*, n. sp., to be described in a further paragraph: The anterior postrostral tooth is placed somewhat, the posterior conspicuously farther behind the orbital margin than in *E. disdorsalis*, the distance from the orbit of the latter tooth averaging 65% in the two available specimens, well outside the extreme range in *E. disdorsalis*. The posterior tooth is continued backward from its sharply cut anterior edge as a high crest. Anterior to the tooth the carina is low; just in front of the tooth it forms a slightly higher elevation terminating in a very short but abrupt descent about a millimeter in front of the tooth.

The rostrum is somewhat shorter and is elevated to a greater angle than is usual in *E. disdorsalis*. The rostrum bears seven teeth in both specimens, of which three form a trifurcate tip; the intermediate of these three terminal teeth is in one specimen represented by no more than a rounded lobe. In one specimen the rostral teeth have the distally concentrated appearance shown in Faxon's figure; in the other the rostrum presents an appearance much like that of *E. disdorsalis*. The lateral ridge of the rostrum runs parallel and very close to the ventral margin, rather than angling up toward the dorsal margin as in *E. disdorsalis*.

The ocular stylets are longer.

Although the anteromedian pleural sulcus proper of the first pleonic somite is as short as in *E. disdorsalis*, this groove in *E. picta* is obscurely continued ventrad by a depression too broad and shallow to be called a sulcus, but not represented in *E. disdorsalis*. On the second and third pleonic somites the posteromedian pleural is distinct from the posterior tergal, which does not extend below the middle of the lateral surface of the somite. An anterior tergal and a short shallow anteromedian pleural are also present.

The first through fourth somites have an anterior ventral angle or spine; only the fifth and sixth bear a posterior ventral spine. The pleural margin dorsad the anterior angle of the first somite is convex, rather than concave. The posterior margins of the posterodorsal clefts of the fourth and fifth somites are not as strongly produced as in *E. disdorsalis*. The tooth in which the carina of the fifth somite terminates posteriorly is considerably produced as a curved spine.

The telson bears a pair of small but conspicuous fixed lateral spines.

The distoventral projection of the petasma is not bifurcate.

E. picta therefore differs from *E. disdorsalis* in precisely the same manner that its Atlantic congener *E. stimpsoni* (Bouvier) differs from *E. dorsalis* (Kingsley), as described by Burkenroad, 1934. Faxon's coupling of *E. picta* with *E. dorsalis* is incorrect, but in his time the latter had not been differentiated from *E. stimpsoni*. It may be noted that Faxon's figure of the telson of *E. picta*, showing lateral spines absent, contradicts the text and is perhaps derived not from the same individual shown in the other figure, but from a specimen of *E. disdorsalis*. However, these figures are not particularly accurate in detail, and the omission of the lateral teeth may be an oversight.

I have not undertaken a direct comparison of *E. picta* with *E. stimpsoni*. The former seems to differ from the Atlantic species by its less deep and inflated carapace, its shorter rostrum in which the two dorsal elements of the trifurcate tip do not extend as far distad as the ventral ones; the shallower sculpture of its pleon, and perhaps in other ways. *E. picta* appears to be less distinct from *E. stimpsoni* than is *E. disdorsalis* from *E. dorsalis*.

The only previous published records of *E. picta*, those of Faxon, refer to greater depths, between 100 and 200 fathoms, and localities considerably to the southward, off the coast of Panama.

***Eusicyonia disdorsalis*, new species**

Figures 25, page 74; and 36, page 91.

1 male, 1 female, types. *B.O.C.* 76. 4 males, 7 females, cotypes. *B.O.C.* 77. Pearl Islands, Gulf of Panama (lat. 8/29/40 N., long. 78/52/30 W.), 19 to 24 fathoms, March 31, 1926.

Dimensions—Range in carapace length, males 8.2 to 13 mm; females 5.8 to 17.6 mm.

In addition to the above specimens, the collection of the Zoology Department of the Peabody Museum of Natural History contains the following material of this species: a male of 8.5 mm carapace length and three females of 7.1 to 11.1 mm carapace length collected on the Pacific coast of Central America by Captain Dow in 1872; a male with the same data of collection 5 mm in carapace length; 6 males ranging from 4 to 5.9 mm in carapace length and 4 females ranging from 4.3 to 6.2 mm in carapace length taken on the Pacific coast of Panama by

Mr. F. H. Bradley in 1868; and a female 6 mm in carapace length with the same data of collection. Whether or not these extra specimens, which were found in different containers than the others with the same data, represent distinct localities, is doubtful; and I am inclined to believe that all of the above material was obtained in the Gulf of Panama.

Description—The dorsal carina of the carapace behind the orbital margin bears two small teeth, the anterior and smaller of which is little more than a third as far from the posteriormost rostral tooth as from the posterior tooth of the carapace, and is about equal to the rostral tooth in size. This anterior tooth of the carapace, which is placed well in front of the level of the hepatic spine, ranges from 6 to 11% of the carapace length behind the orbital margin, modally 8% behind, and averages slightly closer to the margin in small than in large specimens. The posterior tooth, which ranges from 44 to 52% behind the anterior tooth (52 to 61% behind the orbital margin), the modal distance behind the anterior tooth being 50%, averages closer to the anterior tooth in small than in large specimens. The carina behind each of these two teeth, although sharply marked, is very low.

The rostrum ranges in length from 26 to 37% of the carapace length, the average length being about 31%, and is slightly longer in small than in large individuals. The rostrum is usually about horizontal, although it is occasionally somewhat elevated, and has the distal portion conspicuously decurved. The rostrum bears three teeth, rarely four, behind the bifurcate tip. The fifth tooth, the ventralmost of the two terminals, is smaller than the fourth and does not extend as far distad. The distal part of the rostrum beyond the third tooth ranges between 3 and 8% of the carapace in length, the modal extent being 5%. There is a very slight indication that the relative length of this section of the rostrum, in contrast to the relative length of the whole, may increase somewhat with increasing size.

The antennal angle is armed with a short spine.

The ocular stylets are short, not reaching much beyond the narrow base of the ocular peduncle.

The pleonic somites are sculptured as follows: The posteromedian pleural sulcus of the first somite is complete; the anteromedian pleural extends only a short distance ventrad from the anterior margin. The second and third somites bear a posterior tergal reaching nearly to the ventral margin, an anterior tergal reaching the anterior margin some distance above the ventral margin, and a short posteromedian pleural. It is possible that the ventral half of the posterior tergal represents the posteromedian pleural, although there is no trace of a gap between; and that the sulcus here termed posteromedian pleural is actually the anteromedian. The fourth somite bears a posterior tergal only; the fifth both anterior and posterior tergals; and the sixth an anterior tergal and a posteromedian pleural, together with a longitudinal sulcus. All these sulci are very shallow. The surface of the pleon is not tuberculate.

The first to fourth pleonic somites inclusive are armed with an anterior ventral angle, acute in the larger individuals, in which last the third to sixth somites are armed with a spinose posterior ventral angle. The posterior angle loses its boldness with decrease in size of the individual, and in the smallest ones is faintly indicated on the fourth somite only.

The pleural margin just dorsad the anterior angle of the first somite is concave. The relatively well-defined short ventral margin between the angles of each pleuron from first to fourth is convex. The posterior margins of the postero-dorsal clefts of the fourth and fifth somites are produced as long curved spines. The posterior end of the carina of the fifth somite is not produced as a pronounced tooth, although it descends sharply to the apex of the cleft.

The telson bears only the vestiges of a pair of fixed lateral spines.

The distoventral projection of the petasma is bifurcate. Even in the smallest male, in which the endopods are not hooked together, the petasma is of approximately the same form, except that the swelling at the middle of the lateral margins is much less marked. The lower lobe of the bifurcate distoventral projection is always longer and stouter than the distal lobe, and with a much more obtuse tip.

It may be noted that the petasmas were joined in males of more than 6 mm carapace length and even in some of those of smaller size, while the sperm receptacles were impregnated in a female of 6.1 mm carapace length. In individuals of less than 6 mm a pair of mobile lateral spines occur on the telson considerably anterior to the vestiges of the fixed pair. These mobile spines are absent in larger individuals.

E. disdorsalis is the Pacific American congener of the Atlantic *E. dorsalis* (Kingsley), as distinguished from *E. stimpsoni* (Bouvier) in the preceding paper. It is separable from *E. picta* (Faxon), the Pacific American congener of *E. stimpsoni*, by the same characters as distinguish the two Atlantic species. *E. disdorsalis* is distinguishable from *E. dorsalis*, on the basis of comparison with three specimens from Louisiana, the only certainly known in addition to the type, as follows: The anterior tooth of the postrostral carina seems to be set somewhat farther behind the orbital margin in *E. dorsalis*, while the interval between the anterior and posterior teeth is somewhat shorter. The posterior-most rostral tooth is set somewhat closer to the orbital margin, the relative distances in the three specimens falling outside the range in *E. disdorsalis* of comparable size (carapace shorter or longer than 8 mm, respectively). The entire rostrum is somewhat longer; the distal portion is longer; the ventral of the two terminal teeth is smaller relative to the dorsal; and the distal part of the rostrum is not so markedly depressed. The spine of the antennal angle is longer. The pleonic pleural armature is more vigorous; the second somite bearing an acute or spinose posterior ventral angle in large specimens, in which, also, the pleon is somewhat tuberculate. The ventral margins of the first to fourth pleura are concave rather than convex. The ventral furca of the

distoventral projection of the petasma is relatively shorter, slenderer, and with a sharper tip than in *E. disdorsalis*.

SERGESTIDAE Dana

SERGESTINAE Bate

ACETES H. Milne Edwards

Division I, Burkenroad, 1934

Epipodite of the second maxillipede not provided with a podobranch. Rostrum with fewer than two denticles behind the terminal point. Third joint of the inferior antennular flagellum of the male without a large distally directed spine or spines. Coxa of the third legs of the female without a distomedian tooth.

Acetes americanus limonensis, new subspecies

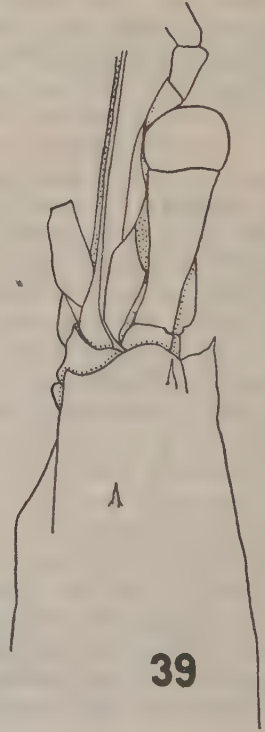
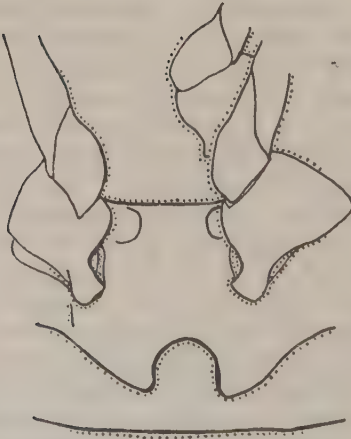
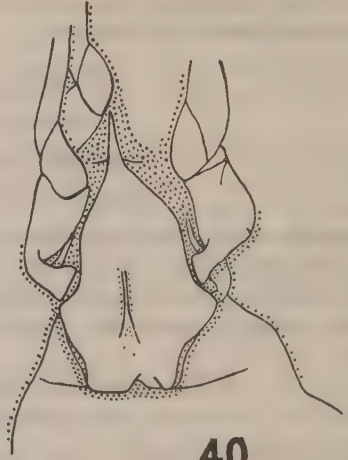
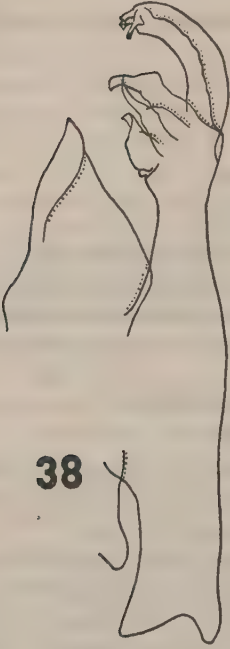
Figures 37 and 38, page 100.

1 male, carapace length 3 mm, total 12 mm; 1 female, carapace 4.1, total 14.3 mm, types; 1 male, cotype. *B.O.C. 104*. Mouth of the Sweetwater River, Limon Bay, Canal Zone, Panama; seine; February 12, 1934.

Description.—Except for its different petasma and female genital sternite, *A. a. limonensis* is indistinguishable from the other described Atlantic forms of the Division which have been reported from Brazil (*A. americanus* Ortmann, 1893, with which *A. brasiliensis* Hansen, 1919, is probably identical), North Carolina (*A. carolinae* Hansen, 1933), and Louisiana (*A. carolinae louisianensis* Burkenroad, 1934, with which the present form has been directly compared).

The petasma in both males of *A. a. limonensis* has a pars externa reaching above the base of the capitulum, but not as high as in the Brazilian specimen figured by Hansen, 1919. The midsection of pars media is somewhat expanded, with a convex, not concave median margin; but is somewhat slenderer than in Louisiana males, and much slenderer than in Hansen's figure of a Brazilian male. It may be noted that the apparent degree of expansion of the midsection of pars media may be affected by the pressure of the cover glass. The capitulum of pars media is less swollen and globose than in the other described forms. The inner lobe of the capitulum is much longer than in the Carolina male figured by Hansen, 1933, and is considerably longer than in Louisiana males, possibly even longer than in the Brazilian form. The tip of the inner lobe is armed with three truncated spines, in contradistinction to specimens from more northerly localities, which usually display only two spines, and to the Brazilian form, reported to bear four spines. The lateral lobes of the capitulum seem to resemble those of the Carolina and Louisiana material in that the chitinous tips of the distal and proximal lobes are flattened and truncate, but to resemble the Brazilian form in the considerable length of the third, distal, lobe.

The breadth of the median emargination of the posterior margin of the genital



sternite of the female is somewhat greater than its length. The anterior margin of the concavity forms a rather shallow arch. The sublateral free projections between which the emargination is enclosed taper to a definite tip, and are slightly incurved; their breadth, measured across the middle of their length, is only slightly less than their length. In these characters the Panamanian specimen seems to fall about midway between Carolina and Brazilian material as figured by Hansen. *A. a. limonensis* differs sharply from Louisiana females by the arched, not straight, anterior outline of the median emargination, and the much shorter, stouter, and less incurved sublateral projections of its genital sternite.

Although the Panamanian material seems rather clearly differentiable from all previously described members of the Division, the allocation to it of a systematic position is fraught with difficulty. There seem, in view of the intermediacy of its characters between those of the southern *A. americanus* Ortmann and of the northern form described by Hansen as *A. carolinae*, only two possible procedures: to describe the present specimens as a distinct species, or to regard all the Atlantic American members of the Division as comprising a single species subject to considerable geographical variation. Since material from each of the four known localities is different from the rest in the characters of its petasma and female genital sternites, and since the material from intermediate localities is also intermediate in structure as compared with the geographical extremes of the series, it seems better to accept the second possibility. The Atlantic American members of Division I are therefore to be regarded as the species *Acetes americanus* Ortmann, ranging from Beaufort, N. C. through the Gulf of Mexico and the Caribbean to the Amazon, and divisible for the present into four local races which further material may indicate to intergrade completely: *A. a. americanus* Ortmann, Brazil; *A. a. limonensis* Burkenroad, Panama; *A. a. louisianensis* Burkenroad, Louisiana; and *A. a. carolinae* Hansen, North Carolina.

***Acetes binghami*,¹ new species**

Figures 39 and 40, page 100.

1 female, subadult, holotype. Carapace 3.2, total length 12.2 mm. *B.O.C.* 105. Bella Vista Beach, Panama City; seine; February 9, 1934.

Description—Epipodite of the second maxilliped without a podobranch.

¹ Named for Mr. Harry Payne Bingham.

Figure 37. *Acetes americanus limonensis*, n. subsp.
Genital sternite $\times 38$.

Figure 38. *Acetes americanus limonensis*, n. subsp.
Left petasmat endopod, dorsal view $\times 87$.

Figure 39. *Acetes binghami*, n. sp.
Carapace, anterior portion, lateral view $\times 17.3$.

Figure 40. *Acetes binghami*, n. sp.
Genital sternite $\times 38$.

Base of the third legs without other armature than the expanded nib at the proximomedian corner of the coxa. Rostrum completely without denticles behind the terminal point; short, with produced slender tip. Transverse diameter of the corneal surface of the eye 38% of the length of the distal segment of the ocular peduncle including the cornea. Second segment of the antennular peduncle 58% as long (measured along the median margin) as the third segment. Inferior antennular flagellum with seven segments, about one-sixth longer than the third segment of the peduncle. Thickened basal portion of the superior antennular flagellum as long as the third segment of the peduncle. Antennal scale extending as far as the basal one-third of the third segment of the antennular peduncle.

Third maxillipedes not extending as far as the basal two-thirds of the antennal scale; third legs not reaching the tip of the scale. Coxal expansions of the third legs rather long, broader at tip than at base, and with a truncated free edge. Ciliated portion of the external margin of the exopod of the uropod 39% of the entire margin, set off from the proximal unciliated portion by a small tooth. Exopod 4.3 times as long as broad; the ciliated portion of its external margin only very shallowly concave. The distal margins of the telson curve inward to two short teeth between which is enclosed the slightly convex posterior margin. There is one stout seta laterad either terminal tooth, and four setae between them.

Genital sternite bearing an escutcheon-shaped elevation, the narrow anterior portion of which extends forward between the bases of the second legs, apparently beyond the suture delimiting the genital sternite. Behind the third legs, the elevated surface is considerably expanded, narrowing again to a subrectangular posterior portion terminated by a straight posterior margin which appears to reach to the boundary between pereion and pleon. This posterior portion is not a free projection. There is a slight longitudinal ridge in the midline of the broadest portion of the elevation. "The sperm receptacles appear to be empty. They evidently open upon the perpendicular margins of the elevation, just anterior to the bases of the third legs.

The holotype is slightly distorted by pressure, and it is probable that the asymmetry displayed by the elevation of the genital sternite, as well as the emargination of the left side of its posterior margin, are artifacts.

Acetes binghami represents the first record of the genus from Pacific America. By the absence of a podobranch from its second maxillipede, the lack of rostral teeth, and the absence of a tooth at the distomedian angle of the coxa of the third legs, it is set apart from the known Indopacific species and the Atlantic American *Acetes paraguayensis* Hansen, and is marked as a member of the peculiarly American Division I, represented in the Atlantic by *A. americanus* Ortmann. It is probable that the male, when discovered, will lack a large anteriorly-directed spine on the third segment of the inferior antennular flagellum, and that its petasma will not be provided with pars astringens.

Acetes binghami differs from *A. americanus* in several characters, but especially in its unique genital sternite. The absence of all rostral denticulation is unique if characteristic, but is possibly not constant; a similar condition has been observed as an exception in a single female of *A. americanus louisianensis* Burkenroad; and the aberrant loss of one of the two denticles of a female of *A. serrulatus* (Krøyer) by Hansen. The basal portion of the superior antennular flagellum seems slightly longer than in *A. a. louisianensis*; the antennal scale does not reach as far, relative to the antennular peduncle; the third maxillipedes and third legs are slightly shorter. These differences are probably of little significance. The exopod of the uropod is slightly broader than in the extreme of the *A. americanus* series, where the length appears to vary from 4.5 to 5 times the width; the ciliated part of the external margin seems clearly less concave than in *A. a. louisianensis*. The coxal projections of the third legs are of somewhat different shape. Finally, the sculpture of the genital sternite, especially the elevation extending anteriorly as a narrowing ridge between the bases of the second legs, is without parallel in the genus.

SUMMARY

A. PENAEIDAE. PENAEINAE.

1. *Penaeopsis* auct. is composed of the three generic groups *Penaeopsis* Bate, restricted; *Metapenaeus* Wood Mason and Alcock, restricted; and *Trachypeneopsis*, new genus. These genera are defined, and the species referable to each are listed; the first mentioned belongs to the **Parapenaeus**, the last two to the **Trachypeneus** series. *Artemesia* Bate, the third genus of the **Parapenaeus** series, is redescribed.
2. *Penaeopsis* Bate, restricted, of which *Leptopenaeus* Kishinouye, *Ceratopenaeus* Kishinouye, and *Erithropenaeus* Kishinouye are synonyms, consists of the two subgenera *Penaeopsis* sensu stricto, and *Metapenaeopsis* Bouvier. The latter, composed of the species with asymmetrical petasma, is divisible into an Eastern Atlantic and American section 1 with atrophied distoventral projection of the left petasmal endopod, and an Indo-Pacific section 2.
3. *Penaeopsis serratus* (Bate), of which *P. challenger* DeMan is a synonym, refers to an Indo-Pacific species. It is possible, as indicated by variation in structure within the Atlantic *P. megalops* (Smith), that *P. serratus* is synonymous with *P. rectacutus* (Bate).
4. The American species of *Metapenaeopsis*, including a new Pacific species, are described and discussed. The closely related West African species of the section is evidently not *Penaeus pubescens* Stimpson, but since this latter appears to be a *Parapeneopsis*, may be known as *Penaeopsis pubescens* (Bouvier).
5. *Metapenaeus* Wood Mason and Alcock is limited (save for historical

migrations) to the Indo-Pacific. Additions are made to the descriptions of several species. The status of a number of named forms related to *M. affinis* (H. M. Edwards), and to *M. ensis* (DeHaan) is doubtful; in addition to these, *Penaeus villosus* Guérin-Mèneville is indeterminable; *M. stebbingi* (Nobili) Schmitt [*Penaeopsis mogiensis* (Rathbun) Balss, part] refers to *Penaeopsis vaillanti* (Nobili); and *Metapenaeus palaestinensis* Steinitz is a *Trachypeneus*, probably a migrant from the Red Sea. The female of *Metapenaeus incisipes* figured by Bate is probably a species of *Parapeneopsis*.

6. The new genus *Trachypeneopsis* is erected for *T. mobilispinis* (Rathbun), and the very closely related Indo-Pacific *T. richtersii* (Miers). The known range of *T. mobilispinis* is extended nine degrees north of the previous record.
7. *Protrachypene precipua*, n. gen. and sp., is an unique Pacific American form in some respects intermediate between *Metapenaeus* and *Trachypeneus*.
8. *Trachypeneus* Alcock is composed of two subgenera, the Indopacific *Trachypeneus sensu stricto*, and the predominantly American *Trachysalambria*, n. subgen. It is possible that the former is more nearly related to the predominantly Indo-Pacific *Parapeneopsis* Alcock than to *Trachysalambria*.
9. Three new forms of *Trachypeneus* (*Trachysalambria*) are described from Pacific America, an area from which the genus has not been previously recorded. One of these is referable to the otherwise Indo-Pacific section 2 of the subgenus while the remaining species are related to Atlantic American forms, one being no more than sub-specifically differentiated from *T. similis* (Smith). Additions are made to the description of the Japanese *T. curvirostris* (Stimpson); it is suggested that more than one Indo-Pacific species of the section may exist.
10. The Indo-Pacific *Parapeneopsis hardwickii* (Miers) and *P. hungerfordi* Alcock are redescribed and their known range considerably extended. *Parapeneopsis sculptilis* var. *cultrirostris* Alcock is probably no more than the normal adult male form. A new species of *Parapeneopsis*, more closely related to *P. atlantica* Balss than to known Indo-Pacific representatives, is described from Pacific America. It is possible that *Penaeus pubescens* Stimpson is referable to the genus, which has otherwise not been previously recorded from America.

B. PENAEIDAE. EUSICYONINAE.

11. *Eusicyonia* Stebbing consists of two fairly distinct divisions, the first cosmopolitan, the second American. Four new Pacific American species and one from the Atlantic are described and compared with

related species. Material indistinguishable from the Atlantic American *E. laevigata* (Stimpson) and *E. brevirostris* (Stimpson) is recorded from Pacific America. *E. carinata americana* (DeMan) is synonymous with *E. laevigata* (Stimpson).

C. SERGESTIDAE. SERGESTINAE.

12. A new subspecies of *Acetes americanus* Ortmann, intermediate between that form and *A. carolinae* Hansen, is described from the Atlantic coast of Panama. It is suggested that *A. carolinae* is a subspecies of *A. americanus*.
13. A new species of *Acetes* from the Bay of Panama, a member of the American Division I, constitutes the first record of the genus from Pacific America.

D. MORPHOLOGY.

14. A generally applicable terminology for the peneid petasma is prepared. The homologies of the asymmetrical petasma with that of other members of the **Parapenaeus** series are discussed. The structure of the petasma of certain members of the **Trachypeneus** series is made known and the various types are compared. Of especial interest is the perfection of the petasma as an injection apparatus in certain species of *Parapeneopsis*, correlated with an extreme specialization of the female receptacles.
15. The internal structure, homologies, and probable mode of operation of the thelycum of a number of Penaeinae are described, including a discussion of certain methods of separation of the entrance and exit to the sperm receptacles.

Figures from camera lucida drawings by the author.

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